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# NUCLEAR SAFETY TECHNICAL REPORT

# SAFETY ANALYSIS FOR RMRS WASTE MANAGEMENT FACILITIES

Rocky Mountain Remediation Services
Nuclear Safety
Rocky Flats Environmental Technology Site



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# ROCKY MOUNTAIN REMEDIATION SERVICES
# NUCLEAR SAFETY
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## EXECUTIVE SUMMARY

This Nuclear Safety Technical Report (NSTR) identifies and evaluates hazards/energy sources, and postulates accident scenarios associated with Rocky Mountain Remediation Services (RMRS) Waste Management Operations performed at the Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado. The purpose of this NSTR is to identify and analyze representative accident scenarios that are applicable during specific "activity modules" and are not necessarily bounding for all waste management facilities/activities. Activity modules are groupings of common sub-activities and include (1) waste storage and handling, (2) waste characterization - chemical, (3) waste characterization - radiological, (4) waste repackaging and treatment, (5) waste generation, and (6) routine activities.

An activity based hazards identification and evaluation of RMRS waste management facilities was performed to identify, evaluate, and control hazards associated with waste container receipt, storage or staging, transfer and shipping operations. The hazard identification process identified 45 hazards or energy sources present in waste management facilities. Of these, 23 hazards or energy sources were determined to be *standard industrial hazards* that are controlled by the Site Safety Management Programs (SMPs) and do not require further evaluation. For the remaining 22 hazards/energy sources, the hazard evaluation process determined how each of the hazards or energy sources could lead to a release of hazardous material. The process identified twelve accident scenarios leading to releases due to failures of waste containers or confinement enclosures:

- Fire Scenario 1 - 1 Mega Watt (MW) Waste Container Fire
- Fire Scenario 2 - 4 MW Waste Container Fire
- Fire Scenario 3 - Small Fire in Repackaging Confinement Enclosure
- Spill Scenario 1 - Container Drop/Fall
- Spill Scenario 2 - Container Puncture (forklift)
- Spill Scenario 3 - Container Puncture (compressed gas cylinder missile)
- Spill Scenario 4 - Breach of Bagged Waste
- Explosion Scenario 1 - TRU Waste Container
- Explosion Scenario 2 - External Explosion in Waste Storage Area
- Natural Phenomena Hazard (NPH) Scenario 1 - Design Basis Earthquake (DBE) Event
- NPH Scenario 2 - Beyond Design Basis Earthquake (BDBE) Event
- Aircraft Crash Scenario 1 - Spill and Fire

These accident scenarios were further refined considering activity modules, container type (*e.g.*, SNM Type B shipping containers, POCs, TRU waste containers, and metal LLW containers), confinement (*e.g.*, glovebox, Perma-Con, contamination cell, etc.), waste type (*e.g.*, LLW, TRU), specific release mechanism, material-at-risk (MAR) quantity (based on container limits), and damage ratio (based on accident progression). This process resulted in the identification of the most representative cases to further analyze. Table 1 provides a summary of the repesentative scenarios including the scenario title, analysis assumptions, scenario frequency, and radiological dose consequences and risk to the public and collocated worker.

The evaluation of representative accident scenarios summarized in Table 1 provides a standardized safety analysis that can be referenced in future revisions to existing Nuclear, Hazard Category 2 and 3 (HC-2, HC-3) waste management facility AB documents as well as during the development of new HC-2 or HC-3 facility AB documents. The safety analysis in this NSTR provides (1) standardized accident scenario descriptions, progressions, and initial condition assumptions; (2) consistent selection, application, and bases of modeling parameters such as scenario type, material-at-risk (MAR), damage ratio (DR), airborne release fraction (ARF), dose conversion factor (DCF), and respirable fraction (RF); (3) a logical identification of controls that can be credited to reduce accident scenario frequencies and/or consequences, and (4) dicussion of control set vulnerability.

It is intended that new and existing facility-specific AB documents will reference this NSTR to the fullest extent possible, noting only those analysis differences that change the results provided herein. Facility-specific AB documents can utilize this NSTR to (1) select applicable representative accident scenarios that will become the "bounding scenarios" for the subject facility; (2) identify facility-specific differences that affect NSTR analysis results (*e.g.*, MOI distance, waste storage quantity and configuration, facility layout and construction, etc.); (3) determine accident frequencies, consequences, and risk classes based on the facility-specific differences; (4) select applicable control requirements; (5) determine and evaluate "risk dominant" accident scenarios; and (6) discuss facility-specific control set vulnerabilities.

This NSTR does not provide rationale for the acceptability of the results presented in Table 1. However, the accident analyses that follow require certain preventive and mitigative controls. These controls are developed in the *Waste Management Facilities Technical Safety Requirements*, provided as a stand-alone document with applicability to individual RMRS waste management facilities. The TSRs include Limiting Conditions for Operation (LCOs) and Administrative Controls (ACs). ACs include specific controls/restrictions (*i.e.*, the administrative equivalent of a hardware requirement) that provide a reduction in postulated accident scenario initiation frequency and/or a reduction in postulated accident scenario consequences. Specific program elements of SMPs that are relied on, as identified in the safety analysis, will be specified in the *Safety Management Programs* chapters of individual facility AB documents.

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**Table 1** Waste Management Facility Representative Accident Scenario Results

| REPRESENTATIVE ACCIDENT SCENARIO | SCENARIO ASSUMPTIONS: ACTIVITY MODULE | SCENARIO TYPE | FORM OF MATERIAL | SOLUBILITY CLASS–DCF[1] | MAR (g) | DAMAGE RATIO | ARF | RF | LPF | BUILDING SOURCE TERM (g) | RELEASE DURATION (minutes) | FREQUENCY | RADIOLOGICAL DOSE & RISK CLASS (MOI @ 1,200 m)[2]: Radiological Dose (rem) 95th χ/Q: CW | Radiological Dose (rem) 95th χ/Q: MOI | Risk Class: CW | Risk Class: MOI | RADIOLOGICAL DOSE & RISK CLASS (MOI @ 2,367 m)[2]: Radiological Dose (rem) 95th χ/Q: CW | Radiological Dose (rem) 95th χ/Q: MOI | Risk Class: CW | Risk Class: MOI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FIRE SCENARIO 1 – 1 MW WASTE CONTAINER FIRE** | | | | | | | | | | | | | | | | | | | | |
| CASE A: 1 Metal LLW Box | SH | Fire Non-lofted | Confined | W | 3 | 1.0 | 5.0E-04 | 1.0 | 1.0 | 1.5E-03 | 10 | U | Low 2.3E-01 | Low 4.8E-03 | III | III | Low 2.3E-01 | Low 1.7E-03 | III | III |
| CASE B: 3 TRU Waste Drums | | | | | 600 | | | | | 3.0E-01 | | | High 4.7E+01 | Moderate 9.6E-01 | I | II | High 4.7E+01 | Moderate 3.4E-01 | I | II |
| **FIRE SCENARIO 2 – 4 MW WASTE CONTAINER FIRE** | | | | | | | | | | | | | | | | | | | | |
| CASE A: 2 Metal LLW Boxes | SH | Fire Non-lofted | Confined | W | 6 | 1.0 | 5.0E-04 | 1.0 | 1.0 | 3.0E-03 | 10 | U | Low 4.7E+01 | Low 9.6E-03 | III | III | Low 4.7E-01 | Low 3.4E-03 | III | III |
| CASE B: 6 TRU Waste Drums | | | | | 1,200 | | | | | 6.0E-01 | | | High 9.3E+01 | Moderate 1.9E+00 | I | II | High 9.3E+01 | Moderate 6.9E-01 | I | II |
| **FIRE SCENARIO 3 – SMALL FIRE IN REPACKAGING CONFINEMENT ENCLOSURE** | | | | | | | | | | | | | | | | | | | | |
| CASE A: LLW (C-cell, Perma-Con) | RT | Fire Non-lofted | Unconfined Combustible | W | 3 | 1.0 | 5.0E-02 | 1.0 | 1.0 | 1.5E-01 | 10 | U | Moderate 2.3E+01 | Moderate 4.8E-01 | II | II | Moderate 2.3E+01 | Moderate 1.7E-01 | II | II |
| CASE B: TRU Waste (Glovebox) | | | | | 320 | | | | 0.001 | 1.6E-02 | | | Moderate 2.5E+00 | Low 5.1E-02 | II | III | Moderate 2.5E+00 | Low 1.8E-02 | II | III |
| **SPILL SCENARIO 1 – CONTAINER DROP/FALL** | | | | | | | | | | | | | | | | | | | | |
| CASE A: 1 Metal LLW Box | SH | Spill | Confined | W | 3 | 1.0 | 1.0E-03 | 0.1 | 1.0 | 3.0E-04 | 10 | A | Low 4.7E+02 | Low 9.6E-04 | III | III | Low 4.7E-02 | Low 3.4E-04 | III | III |
| CASE B: 1 Metal TRU Box/SWB | | | | | 320 | | | | | 3.2E-02 | | | Moderate 5.0E+00 | Low 1.0E-01 | I | III | Moderate 5.0E+00 | Low 3.7E-02 | I | III |
| **SPILL SCENARIO 2 – CONTAINER PUNCTURE (forklift)** | | | | | | | | | | | | | | | | | | | | |
| CASE A: 1 Metal LLW Box | SH | Spill | Unconfined | W | 3 | 0.1 | 1.0E-03 | 1.0 | 1.0 | 3.0E-04 | 10 | U | Low 4.7E-02 | Low 9.6E-04 | III | III | Low 4.7E-02 | Low 3.4E-04 | III | III |
| CASE B: 2 TRU Waste Drums | | | | | 400 | | | | | 4.0E-02 | | | Moderate 6.2E+00 | Moderate 1.3E-01 | II | II | Moderate 6.2E+00 | Low 4.6E-02 | II | III |
| **SPILL SCENARIO 3 – CONTAINER PUNCTURE (compressed gas cylinder missile)** | | | | | | | | | | | | | | | | | | | | |
| CASE A: 1 Metal LLW Box | SH | Spill | Confined | W | 3 | 1.0 | 1.0E-03 | 0.1 | 1.0 | 3.0E-04 | 10 | EU | Low 4.7E-02 | Low 9.6E-04 | IV | IV | Low 4.7E-02 | Low 3.4E-04 | IV | IV |
| CASE B: 3 TRU Waste Drums | | | | | 600 | | | | | 6.0E-02 | | | Moderate 9.3E+00 | Moderate 1.9E-01 | III | III | Moderate 9.3E+00 | Low 6.9E-02 | III | IV |
| **SPILL SCENARIO 4 – BREACH OF BAGGED WASTE** | | | | | | | | | | | | | | | | | | | | |
| CASE A: LLW (C-cell, Perma-Con) | RT | Spill | Unconfined Combustible | W | 3 | 1.0 | 1.0E-03 | 1.0 | 0.1 | 3.0E-04 | 10 | A | Low 4.7E-02 | Low 9.6E-04 | III | III | Low 4.7E-02 | Low 3.4E-04 | III | III |
| CASE B: 3 TRU Waste (Outside Glovebox, Inside Confinement Area) | | | | | 320 | | | | 0.001 | 3.2E-04 | | | Low 5.0E-02 | Low 1.0E-03 | III | III | Low 5.0E-02 | Low 3.7E-04 | III | III |
| **EXPLOSION SCENARIO 1 – TRU WASTE CONTAINER** | SH | Overpressure | Powder | W | 320 | 0.1 | 1.0E-01 | 0.7 | 1.0 | 2.2E-02 | 10 | EU | High 3.5E+02 | High 7.2E+00 | II | II | High 3.5E+02 | Moderate 2.6E+00 | II | III |
| **EXPLOSION SCENARIO 2 – EXTERNAL EXPLOSION IN WASTE STORAGE AREA** | | | | | | | | | | | | | | | | | | | | |
| CASE A: Medium Construction Facility | RA | Spill | Confined | W | 342,000 | 0.0015 | 1.0E-03 | 0.1 | 1.0 | 5.1E-02 | 10 | EU | Moderate 5.6E+00 | Moderate 1.2E-01 | III | III | Moderate 5.6E+00 | Low 4.1E-02 | III | IV |
| CASE B: Substantial Construction Facility | | | | | | 0.01 | | | | 3.4E-01 | | | High 3.7E+01 | Moderate 7.7E-01 | II | III | High 3.7E+01 | Moderate 2.7E-01 | II | III |

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# **Table 1** Waste Management Facility Representative Accident Scenario Results

| REPRESENTATIVE ACCIDENT SCENARIO | SCENARIO ASSUMPTIONS | | | | | | | | | | | | RADIOLOGICAL DOSE & RISK CLASS (MOI @ 1,200 m)[2] | | | | RADIOLOGICAL DOSE & RISK CLASS (MOI @ 2,367 m)[2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACTIVITY MODULE | SCENARIO TYPE | FORM OF MATERIAL | SOLUBILITY CLASS–DCF[1] | MAR (g) | DAMAGE RATIO | ARF | RF | LPF | BUILDING SOURCE TERM (g) | RELEASE DURATION (minutes) | FREQUENCY | Radiological Dose (rem) 95th χ/Q | | Risk Class | | Radiological Dose (rem) 95th χ/Q | | Risk Class | |
| | | | | | | | | | | | | | CW | MOI | CW | MOI | CW | MOI | CW | MOI |
| **NPH SCENARIO 1 – DBE EVENT**<br>CASE A: Medium Construction Facility | SH | Spill | Confined | B | 342,000 | 0.0015 | 1.0E-03 | 0.1 | 1.0 | 5.1E-02 | 10 | U | Moderate<br>5.6E+00 | Moderate<br>1.2E-01 | II | II | Moderate<br>5.6E+00 | Low<br>4.1E-02 | II | III |
| CASE B: Substantial Construction Facility | | | | | | 0.01 | | | | 3.4E-01 | | | High<br>3.4E+01 | Moderate<br>7.7E-01 | I | II | High<br>3.4E+01 | Moderate<br>2.7E-01 | I | II |
| **NPH SCENARIO 2 – BDBE EVENT**<br>CASE A: Light Construction Facility | SH | Spill | Confined | B | 1,440 | 0.02 | 1.0E-03 | 0.1 | 1.0 | 2.9E-03 | 10 | U | Low<br>3.2E-01 | Low<br>6.5E-03 | III | III | Low<br>3.2E-01 | Low<br>2.3E-03 | III | III |
| CASE B: Medium Construction Facility (falling debris) | SH | Spill | Confined | B | 342,000 | 0.007 | 1.0E-03 | 0.1 | 1.0 | 2.3E-01 | 10 | U | 2.6E+01 | 5.4E-01 | – | – | 2.6E+01 | 1.9E-01 | – | – |
| CASE B: Medium Construction Facility (toppling) | | | | | 684,000 | 0.02 | | | | 1.4E+00 | | | 1.5E+02 | 3.1E+00 | – | – | 1.5E+02 | 1.1E+00 | – | – |
| CASE B: Medium Construction Facility - <u>TOTAL</u> | | | | | 1,026,000 | – | | | | 1.6E+00 | | | High<br>1.8E+02 | Moderate<br>3.6E+00 | I | II | High<br>1.8E+02 | Moderate<br>1.3E+00 | I | II |
| CASE C: Substantial Construction Facility (falling debris) | SH | Spill | Confined | B | 342,000 | 0.05 | 1.0E-03 | 0.1 | 1.0 | 1.7E+00 | 10 | U | 1.9E+02 | 3.8E+00 | – | – | 1.9E+02 | 1.4E+00 | – | – |
| CASE C: Substantial Construction Facility (toppling) | | | | | 684,000 | 0.02 | | | | 1.4E+00 | | | 1.5E+02 | 3.1E+00 | – | – | 1.5E+02 | 1.1E+00 | – | – |
| CASE C: Substantial Construction Facility - <u>TOTAL</u> | | | | | 1,026,000 | – | | | | 3.1E+00 | | | High<br>3.4E+02 | High<br>6.9E+00 | I | I | High<br>3.4E+02 | Moderate<br>2.5E+00 | I | II |
| **AIRCRAFT CRASH SCENARIO 1 – SPILL AND FIRE**<br>CASE A: LLW Drums | SH | Spill | Confined | B | 35 | 1.0 | 1.0E-03 | 0.1 | 1.0 | 3.5E-03 | 10 | EU | 3.8E-01 | 7.9E-03 | – | – | 3.8E-01 | 2.8E-03 | – | – |
| | | Fire, Lofted | Unconfined Combustible | | 35 | | 5.0E-02 | 1.0 | | 1.8E+00 | | | 6.9E+00 | 2.0E-01 | – | – | 6.9E+00 | 2.0E-01 | – | – |
| | | Fire, Lofted | Confined | | 205 | | 5.0E-04 | 1.0 | | 1.03E-01 | | | 4.1E-01 | 1.2E-02 | – | – | 4.1E-01 | 1.2E-02 | – | – |
| CASE A: <u>TOTAL</u> | | Spill & Fire | – | | 240 | | – | – | | 1.9E+00 | | | Moderate<br>7.7E+00 | Moderate<br>2.1E-01 | III | III | Moderate<br>7.7E+00 | Moderate<br>2.1E-01 | III | III |
| CASE B: TRU Waste Drums | SH | Spill | Confined | B | 14,000 | 1.0 | 1.0E-03 | 0.1 | 1.0 | 1.4E+00 | 10 | EU | 1.5E+02 | 3.2E+00 | – | – | 1.5E+02 | 1.1E+00 | – | – |
| | | Fire, Lofted | Unconfined Combustible | | 14,000 | | 5.0E-02 | 1.0 | | 7.0E+02 | | | 2.8E+03 | 7.9E+01 | – | – | 2.8E+03 | 7.9E+01 | – | – |
| | | Fire, Lofted | Confined | | 82,000 | | 5.0E-04 | 1.0 | | 4.1E+01 | | | 1.6E+02 | 4.6E+00 | – | – | 1.6E+02 | 4.6E+00 | – | – |
| CASE B: <u>TOTAL</u> | | Spill & Fire | – | | 96,000 | | – | – | | 7.4E+02 | | | High<br>3.1E+03 | High<br>8.4E+01 | II | II | High<br>3.1E+03 | High<br>8.4E+01 | II | II |
| CASE C: POCs | SH | Spill | Powder | B | 8,830 | 0.1 | 2.0E-03 | 0.01 | 1.0 | 1.7E-02 | 10 | EU | 2.7E+00 | 5.6E-02 | – | – | 2.7E+00 | 2.0E-02 | – | – |
| | | Fire, Lofted | Unconfined Combustible | | 8,830 | 0.1 | 5.0E-02 | | | 4.4E-01 | | | 2.4E+00 | 6.9E-02 | – | – | 2.4E+00 | 6.9E-02 | – | – |
| | | Fire, Lofted | Confined | | 8,830 | 0.9 | 5.0E-04 | | | 4.0E-02 | | | 2.2E-01 | 6.2E-03 | – | – | 2.2E-01 | 6.2E-03 | – | – |
| CASE C: <u>TOTAL</u> | | Spill & Fire | – | | 8,830 | – | – | | | 5.0E-01 | | | Moderate<br>5.3E+00 | Low<br>7.5E-02 | III | IV | Moderate<br>5.3E+00 | Low<br>7.5E-02 | III | IV |

1. When "B" is annotated in the Solubility Class – DCF column a blended DCF was use to model the scenario. The blended DCF for LLW is 3.07E+07 rem/g-mix and the blended DCF for TRU waste is 3.04E+07 rem/g-mix.
2. For Aircraft Crash Scenario 1 – Spill and Fire, the radiological dose consequences for the MOI due to the lofted fire portion of the table is for the MOI at 4,200 m due to lofting.

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# ACRONYMS

| | |
|---|---|
| A | Anticipated [event frequency bin] |
| ADB | Analyzed in Detail Below |
| ALARA | As-Low-As-Reasonably-Achievable |
| AOL | Administrative Operating Limit |
| ARRF | Airborne Respirable Release Fraction |
| BDBE | Beyond Design Basis Earthquake |
| BR | Breathing Rate |
| C | Credited [protective feature] |
| CC | Waste Characterization – Chemical (activity module) |
| CEDE | Committed Effective Dose Equivalent |
| CFR | Code of Federal Regulation |
| CONFIG | Configuration Management (SMP) |
| COOP | Conduct of Operations (SMP) |
| CR | Waste Characterization – Radiological (activity module) |
| CRIT | Criticality Safety (SMP) |
| CW | Collocated Worker |
| D | Defense-In-Depth [protective feature] |
| DID | Defense-In-Depth [protective feature] |
| DBE | Design Basis Earthquake |
| DCF | Dose Conversion Factor |
| DOE | Department Of Energy |
| DOT | Department Of Transportation |
| DR | Damage Ratio |
| E | Extremely Unlikely [event frequency bin] |
| EE | External Event |
| EFCOG | Energy Facility Contractors Group |
| EP | Emergency Preparedness (SMP) |
| EPA | Environmental Protection Agency |
| ERPG | Emergency Response Planning Guideline |
| FHA | Fire Hazards Analysis |
| FIRE | Fire Protection (SMP) |
| FPE | Fire Protection Engineering |



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| | |
|---|---|
| FSAR | Final Safety Analysis Report |
| GN | Waste Generation (activity module) |
| HEPA | High Efficiency Particulate Air [filters] |
| HMP | Hazardous Materials Protection (SMP) |
| ICMS | Integrated Chemical Management System |
| IDC | Item Description Code |
| INS | Industrial Safety (SMP) |
| IST | Initial [respirable] Source Term |
| IW | Immediate Worker |
| LCO | Limiting Condition for Operation |
| LLW | Low-Level Waste |
| LPF | Leakpath Factor |
| LS/DW | Life Safety / Disaster Warning [system] |
| M | Mitigative [protective feature] |
| MAR | Material-At-Risk |
| MOI | Maximum [exposed] Off-site Individual |
| NA | Not Applicable |
| NDT | Non-Destructive Testing |
| NFPA | National Fire Protection Association |
| NMSL | Nuclear Material Safety Limit |
| NPH | Natural Phenomena Hazard |
| NSTR | Nuclear Safety Technical Report |
| NUC | Nuclear Safety (SMP) |
| OR | Occurrence Reporting (SMP) |
| ORG | Organization and Management (SMP) |
| P | Preventive [protective feature] |
| PC | Performance Category |
| PCB | Polychlorinated-Biphenyl |
| PDC | Plume Duration Correction [factor] |
| PHA | Preliminary Hazards Analysis |
| POC | Pipe Overpack Container |
| PROC | Procedures (SMP) |
| PSM | Process Safety Management |

| | |
|---|---|
| QA | Quality Assurance (SMP) |
| RA | Routine Activities (activity module) |
| RAD | Radiation Protection (SMP) |
| RCRA | Resource Conservation and Recovery Act |
| RQ | Reportable Quantity |
| RT | Repackaging and Treatment (activity module) |
| SAR | Safety Analysis Report |
| SARAH | Safety Analysis and Risk Assessment Handbook |
| SC | System Category |
| SH | Shipping and Handling (activity module) |
| SMP | Safety Management Program |
| SNM | Special Nuclear Material |
| SSC | Structure, System, and Component |
| SWB | Standard Waste Box |
| TPQ | Threshold Planning Quantity |
| TQ | Threshold Quantity |
| TRAIN | Training (SMP) |
| TRU | Transuranic |
| TRUPACT | Transuranic Package Transporter |
| TSCA | Toxic Substances Control Act |
| TS&M | Training, Surveillance, and Maintenance (SMP) |
| TSR | Technical Safety Requirement |
| U | Unlikely [event frequency bin] |
| UCL | Upper Confidence Limit |
| USQD | Unreviewed Safety Question Determination |
| WEMS | Waste and Environmental Management System |
| WFC | Waste Form Code |
| WG Pu | Weapons Grade Plutonium |
| WMEP | Waste Management and Environmental Protection (SMP) |
| WORK | Work Control (SMP) |
| $\chi/Q$ | Chi-over-Q (atmospheric dispersion factor) |



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## ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of Jeff Conyers and Alan Hohl in the development of this report. Also, the authors wish to acknowledge the report reviewers (Babette Meale and Don Swanson) for their efforts to review the report in a timely fashion and for their comments that lead to an overall improvement in the report quality.

# 1. INTRODUCTION

## 1.1 PURPOSE

This Nuclear Safety Technical Report (NSTR) identifies and evaluates hazards/energy sources, and postulates accident scenarios associated with Rocky Mountain Remediation Services (RMRS) Waste Management Operations performed at the Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado. The purpose of this NSTR is to identify and analyze representative accident scenarios that are applicable during specific "activity modules" and are not necessarily bounding for all waste management facilities/activities. Activity modules are groupings of common sub-activities and include (1) waste storage and handling, (2) waste characterization - chemical, (3) waste characterization - radiological, (4) waste repackaging and treatment, (5) waste generation, and (6) routine activities. Activity modules and associated sub-activities are further discussed in Section 1.4.

Evaluation of representative accident scenarios provides a standardized safety analysis that can be referenced in future revisions to existing Nuclear, Hazard Category 2 and 3 (HC-2, HC-3) waste management facility AB documents as well as during the development of new HC-2 or HC-3 facility AB documents. The safety analysis in this NSTR provides (1) standardized accident scenario descriptions, progressions, and initial condition assumptions; (2) consistent selection, application, and bases of modeling parameters such as scenario type, material-at-risk (MAR), damage ratio (DR), airborne release fraction (ARF), dose conversion factor (DCF), and respirable fraction (RF); (3) a logical identification of controls that can be credited to reduce accident scenario frequencies and/or consequences; and (4) dicussion of control set vulnerability.

It is intended that new and existing facility-specific AB documents will reference this NSTR to the fullest extent possible, noting only those analysis differences that change the results provided herein. Facility-specific AB documents can utilize this NSTR to (1) select applicable representative accident scenarios that will become the "bounding scenarios" for the subject facility; (2) identify facility-specific differences that affect NSTR analysis results (*e.g.*, MOI distance, waste storage quantity and configuration, facility layout and construction, etc.); (3) determine accident frequencies, consequences, and risk classes based on the facility-specific differences; (4) select applicable control requirements; (5) determine and evaluate "risk dominant" accident scenarios; and (6) discuss facility-specific control set vulnerabilities.

The organization of this NSTR includes the following chapters:

Chapter 1 Introduction: Discusses the purpose/need for this NSTR; identifies waste types, container types, confinement enclosures, facilities, and activity modules addressed in the safety analysis.

Chapter 2 Hazard and Accident Analysis Introduction: Introduces the nuclear safety hazard identification and evaluation process as it applies to RMRS waste management facilities/activitiy modules.

Chapter 3 Requirements: Identifies standards, regulations, and DOE Orders that were reviewed in support of the development of this NSTR.



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Chapter 4 — Methodology: Describes the hazards and accident analysis processes used to determine representative accident scenarios that are further evaluated in subsequent chapters.

Chapter 5 — Hazard Identification and Description: Identifies and describes the hazards/energy sources that may contribute to a radiological and/or toxicological release. Includes a general hazard identification checklist and a hazard description summary table.

Chapter 6 — Hazard Evaluation and Selection of Accident Scenarios Requiring Further Analysis: Evaluates hazards not categorized as *standard industrial hazards,* and postulates how such hazards can lead to radiological/toxicological releases due to waste container failures or confinement enclosure failures (*e.g.*, glovebox, Perma-Con, contamination cell, etc.). Identifies accident scenarios requiring further analysis.

Chapter 7 — Accident Analysis Process: Describes the accident analysis process as applied to accident scenarios requiring further analysis that were carried forward from Chapter 6. Includes sections that address accident scenario discussion format and accident scenario summary format.

Chapter 8 — Storage and Handling (SH) Accident Analysis: Presents the accident analysis of fire, spill, NPH and explosion scenarios associated with waste management facility SH activities.

Chapter 9 — Waste Characterization – Chemical (CC) Accident Analysis: Presents the accident analysis of fire, spill, and explosion scenarios associated with waste management facility CC activities. This chapter will be completed in a future revision to this NSTR.

Chapter 10 — Waste Characterization – Radiological (CR) Accident Analysis: Presents the accident analysis of fire, spill, and explosion scenarios associated with waste management facility CR activities. This chapter will be completed in a future revision to this NSTR.

Chapter 11 — Repackaging and Treatment (RT) Accident Analysis: Presents the accident analysis of fire and spill scenarios associated with waste management facility RT activities.

Chapter 12 — Waste Generation (GN) Accident Analysis: Presents the accident analysis of fire, spill, and explosion scenarios associated with waste management facility GN activities. This chapter will be completed in a future revision to this NSTR.

Chapter 13 — Routine Activities (RA) Accident Analysis: Presents the accident analysis of spill and facility explosion scenarios associated with waste management facility RA activities.

Chapter 14 — Derivation of Technical Safety Requirements: Explains how the *Waste Management Facilities Technical Safety Requirements* (Ref. 1) were developed from the hazard identification/evaluation and accident analysis processes and discusses the control types used.

Chapter 15 — References: Provides a list of references cited throughout the NSTR.

## 1.2 SCOPE

The RMRS waste management facilities within the scope of this safety analysis include:

- Building 440
- Building 569
- Building 664 Complex
- Building 666
- 750/904 Pads
- Building 906
- Building 991 Complex
- RCRA Storage Units

This NSTR demonstrates understanding and adequate control of potential hazards associated with the above listed RMRS waste management facilities and their associated waste management operations and activities. Definitions and descriptions of the various waste types, container types, and waste management facilities are briefly discussed in the following sections to facilitate a better understanding of the safety analysis. Waste management activities are also described and were grouped by combining common sub-activities based on individual activity descriptions (*e.g.*, storage, characterization, repackaging, generation, etc.), waste type (*e.g.* transuranic (TRU), low level (LL), hazardous (HAZ)), and whether primary confinement is breached under normal operating conditions (*e.g.*, repackaging requires breaching the waste container, storage does not). Information pertaining to Site characteristics necessary for understanding the facility environments are addressed in the Site Safety Analysis Report (Site SAR) (Ref. 2). The Site SAR addresses such items as Site description, environmental description, natural phenomena threats, external man-made threats, nearby facilities, and validity of existing environmental analyses.

## 1.3 DEFINITIONS AND DESCRIPTIONS

This section presents a set of definitions and descriptions of waste types and waste containers pertinent to this NSTR. It also provides a brief synopsis of those waste operations facilities, their associated waste management activities, and waste facility interfaces covered by this NSTR. It is intended to provide an overview of the waste operations facilities whose activities are subsequently analyzed in the hazard and accident analyses. The facility descriptions provide the reader with information helpful to understanding the scope of the safety analysis and derivation of the Technical Safety Requirements (TSRs) presented in this NSTR.

### 1.3.1 Waste Types

Hazardous Waste (HAZ)

Hazardous (HAZ) waste is that waste having hazardous Environmental Protection Agency codes for ignitability, corrosivity, reactivity, and metals assigned, but which has no radioactive component. HAZ waste was generated from routine production and production support activities and will continue to be generated during decommissioning and decontamination (D & D) and environmental remediation activities. Hazardous waste is stored in Buildings 440, 569, 664 and 906, the 750/904 Pads, and in the Resource Conservation and Recovery Act (RCRA) Units.



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Toxic Substances Control Act (TSCA) Waste

Toxic Substances Control Act (TSCA) waste is that waste contaminated with polychlorinated biphenyls (PCBs) and asbestos. There are four types of TSCA waste associated with RFETS, (a) non-radioactive, non-friable asbestos waste, (b) radioactively-contaminated asbestos waste, (c) waste contaminated with PCBs, and (d) radioactive waste contaminated with PCBs. TSCA waste is stored in Buildings 440 and 666.

Low Level (LL) Waste

Low level (LL) waste is that waste contaminated with a radioactive constituents that remain below 100 nanocuries per gram (nCi/g) and has no hazardous Environmental Protection Agency codes for ignitability, corrosivity, reactivity, or metals assigned, or is a listed waste. LL waste was generated from routine production and production support activities and will continue to be generated during decommissioning and decontamination (D & D) activities. LL waste is stored in Buildings 440, 569, 664, 906, and 991, the 750/904 Pads, and in the RCRA Units.

Low Level Mixed (LLM) Waste

Low level Mixed (LLM) waste is that waste contaminated with a radioactive constituents that remain below 100 nanocuries per gram (nCi/g) activity and also has hazardous Environmental Protection Agency codes for ignitability, corrosivity, reactivity, or metals assigned, or is a listed waste. LLM waste was generated from routine production and production support activities and will continue to be generated during decommissioning and decontamination (D & D) activities. LLM waste is stored in Buildings 440, 569, 664, 906, and 991, the 750/904 Pads, and in the RCRA Units.

Transuranic (TRU) Waste

Transuranic (TRU) waste is that waste contaminated with a radioactive constituents that are at or above 100 nanocuries per gram (nCi/g) and has no hazardous Environmental Protection Agency codes for ignitability, corrosivity, reactivity, or metals assigned, or is a listed waste TRU waste was generated from routine production and production support activities and will continue to be generated during decommissioning and decontamination (D & D) activities. TRU waste is stored in Buildings 440, 569, 664, and 991, the 750/904 Pads, and in the RCRA Units.

Transuranic Mixed (TRM) Waste

Transuranic mixed (TRM) waste is that waste contaminated with a radioactive constituents that are at or above 100 nanocuries per gram (nCi/g) activity and also has hazardous Environmental Protection Agency codes for ignitability, corrosivity, reactivity, or metals assigned, or is a listed waste. TRM waste was generated from routine production and production support activities and will continue to be generated during decommissioning and decontamination (D & D) activities. TRM waste is stored in Buildings 440, 569, 664, and 991, the 750/904 Pads, and in the RCRA Units.

Category I/II Special Nuclear Material

Category I and II Special Nuclear Material (SNM) quantities of plutonium, uranium, and americium metals and oxides are staged in Type B DOT containers in Building 991. The Category I and II SNM is compliant with 1-W89-HSP-31.11, onsite transportation procedures, and DOT procedures limiting the amount of known pyrophoric material.

### 1.3.2 Waste Container Types

The waste container types used for packaging and storing radiological and chemical wastes in waste management facilities are listed in Table 1-1 and are described in greater detail below. The On-Site Transportation of Hazardous and Radioactive Materials Manual (Ref. 3) contains the specifications for all of the waste containers used onsite except SWBs, which are procured from the Waste Isolation Pilot Plant (WIPP) in accordance with their specifications.

10-gallon Drums

10-gallon drums (DOT Specification 6C container) are metal containers that may have a cylindrical spacer, an inner container, and two (2) stainless steel Volrath cans with bolted lids. The 10-gallon drums may contain non-radioactively contaminated hazardous chemical wastes.

30-gallon Drums

30-gallon drums (DOT Specification 17H container per 49 CFR 178.354) are metal drums having Celotex ™ insulation and may have gasket, inner fiberboard boxes, poly vinyl chloride (PVC) plastic bags, or vials. 30-gallon drums may contain one (1) or two (2) inner stainless steel containment vessels, each having a bolted lid. When assembled and filled as specified, a 30-gallon drum is a DOT Type B container (DOT 6M specification).

35-gallon Drums

35-gallon drums are Sizing and Reduction Facility (SARF) drums (DOT Specification 17C containers per 49 CFR 178.115) used for TRU waste. 35-gallon metal drums may have a metal closure ring, a drum gasket, two (2) PVC liners or glovebox bags, a fiberboard liner, and a carbon filter in the drum lid.

55-gallon Drums

55-gallon drums (DOT Specification 17C containers per 49 CFR 178.115) are DOT Specification 7A Type A packages meeting the requirements and restrictions outlined in 49 CFR 173.411, 49 CFR 173.412 and 49 CFR 173.350. 55-gallon drums are of steel-welded construction with a metal closure ring, polyethylene rigid liner, PVC or plastic bottom liner, drum gasket, and a carbon filter in the drum lid. 55-gallon drums are white epoxy painted. Maximum gross weight capacity: 800 pounds. Up to fourteen (14) 55-gallon drums may be loaded into a TRUPACT II container. Three (3) TRUPACT II containers are normally transported on a TRUPACT II Transporter Trailer, a modified flatbed truck.

82 gallon Overpack Container

Waste drums with either suspect or verified integrity conformance problems are placed into 82-gallon polyethylene drum overpack containers to contain contamination before placement into storage arrays.

TRUPACT II Metal Standard Waste Boxes

TRUPACT II corrugated steel Standard Waste Boxes (SWB), metal Sandia ("SAND") Boxes (both DOT Specification 32B containers per 49 CFR 178.147, 178.350), are DOT Type A packages meeting the requirements and restrictions outlined in 49 CFR 173.411, 49 CFR 173.412 and 49 CFR 173.350. "SAND" boxes are constructed of steel with a fiberboard liner, a PVC liner, and a carbon filter. SWBs are of low-carbon steel construction with a gasketed steel lid, and one (1) filter vent. Two (2) SWBs may be loaded into a TRUPACT II container. Three (3) TRUPACT II containers are normally transported on a TRUPACT II Transporter Trailer, a modified flatbed truck.

Plywood Crates

Flush-panel plywood boxes are "strong outer package" containers and liners (properly assembled) used for exclusive-use common carrier shipments of Low Specific Activity (LSA) waste materials, as allowed by 49 CFR 173.24, 173.425(b). These full and half crate containers may have PVC liners, or fiberboard liners and are used for HAZ, LL, and LLM wastes, which fall under the category of LSA materials as defined in 49 CFR 173.403(n). The plywood crates may be required to be painted white (per Underwriters Laboratory [UL] Class A fire retardancy). Maximum gross weight capacities: full crate: 5000 pounds; half-crate: 5000 pounds. [***Note: the hazard and accident analysis in this NSTR does not presently address the use of wooden waste crates.***]



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Metal Boxes

The M-, I-, and V-boxes are fabricated using sheet metal with welded seams. The M-boxes are constructed of corrugated sheet metal and have fiberglass lids; the I- and V-boxes have metal lids.

- M-Box

  M-Boxes are metal containers fabricated from corrugated sheet metal with welded seams and a fiberglass lid. Maximum gross weight capacity: 6000 pounds.

- I-Box

  I-Boxes are metal containers fabricated from corrugated sheet metal with welded seams and a metal lid. Maximum gross weight capacity: 3000 pounds.

- V-Box

  V-Boxes are metal containers fabricated from corrugated sheet metal with welded seams and a metal lid. Maximum gross weight capacity: 3000 pounds.

Triwall Boxes

Triwall boxes measuring 39.5 in × 39.5 in × 22 in (20 $ft^3$) are used to store Pondcrete and Saltcrete waste and are overpacked in metal boxes. A triwall box is a corrugated fiberboard package consisting of a triple-wall body, outer and inner caps, a PVC liner, and nonmetallic strapping. Because of deterioration and to maintain contamination and inventory control, most triwall boxes are double-wrapped with plastic sheet material and stored in M-, I-, and V-boxes. Maximum gross weight capacity: 2000 pounds.

IP-2 Metal Box

The IP-2 containers are welded metal, top-loading waste containers with skids, gasket, and a carbon filter vent. The IP-2 containers have welded inserts to allow lid removal and replacement by forklift. Both the full and half size, white epoxy-painted, IP-2 containers meet DOT 49 CFR 173.411, 173.410, 173.465, and 173.461 requirements. IP-2 containers have replaced wooden waste crates at RFETS. Maximum gross weight capacity: full: 6000 pounds; half: 6000 pounds.

Pipe Overpack Containers (POCs)

The POC consists of a sealed pipe component (Schedule 40 pipe with 6-inch diameter or Schedule 20 pipe with 12-inch diameter, 25 inches long), contained within a Type 17C 55-gallon drum. The pipe component is separated from the drum by fiberboard packing material and a plastic liner. The lids of both the drum and the pipe component have filtered vents. The POC qualifies as a Type A package. Waste will not be placed directly into the pipes. Rather, the waste will be placed in secondary containers, which will then be placed in the pipes. The secondary containers are not credited for mitigating a release. The POC does not qualify as a Type B container because it was not subjected to the complete Type B protocol testing program.

ATMX and Yard Cargo Containers

Two types of cargo containers are used effectively as pallets with sides and tops for container management purposes. ATMX cargo containers are 8ft × 8ft × 20ft. Yard cargo containers are typically 8ft × 8ft × 20ft or 8ft × 8ft × 40ft. The ATMX cargo container can be used for storing TRU or LL waste. Yard cargo containers are used for yard storage of LL waste.

275 gallon and 10,000 gallon Waste Storage Tanks

The 10,000-gallon tanks are used as primary storage of LLM Solar Pond Sludge on the 750 Pads. Sludges will be transferred to the 275-gallon tanks described below prior to onsite treatment or shipment offsite for treatment/disposal. The 10,000-gallon tanks consist of an inner primary tank with a diameter of approximately 13.5 ft and an outer tank with a diameter of approximately 14 ft. The outer tank has no lid. Leak detection capability for leaks from the primary tank into the secondary tank is provided. Each tank set has a maximum nominal capacity of 11,500 gallons and a nominal working volume of 10,000 gallons.

The 275-gallon tanks are used to store LLM Solar Pond Sludge on the 750 Pads pending either onsite treatment or shipment to an offsite waste treatment/disposal site. The 275-gallon tanks are constructed of rigid plastic and meet United Nations (UN)/Department of Transportation (DOT) certifications: Packing Groups II & III, 31H2 & 31HH2 (HM-181E). The cylindrical 46 inch diameter × 54 inch tall tanks rest on fitted polyethylene pallets and they are approved by the Onsite Transportation Committee for onsite transfer. Secondary containment is provided by catch basins in accordance with the RFETS RCRA Permit.

HEPA Filter Shipping Container

HEPA Filter Shipping Containers (filter coffin) are constructed of welded stainless steel and have a carbon composite filter. The package is used to transport used HEPA filters onsite for repackaging and disposal.

Sample Transfer Containers

One (1)-gallon (paint can), 12-gallon and 54-gallon sample transfer containers (coolers) are used to transfer waste samples in polyethylene or glass vials to on-site laboratories for analytical testing. Sample transfer containers may be Volrath cans and may contain vermiculite absorbent.

**Table 1-1** Waste Container Types

| CONTAINER | VOLUME | COMMON NOMENCLATURE |
|---|---|---|
| 10-gallon drums | 1 $ft^3$ | "non-radioactive container" |
| 30-gallon drums | 4 $ft^3$ | "ERW drum" |
| 35-gallon drums | 5 $ft^3$ | "SARF drum" |
| 55-gallon drums | 7.4 $ft^3$ | "drum" |
| 82-gallon drum, | 11 $ft^3$ | "overpack" |
| TRUPACT II Metal Standard Waste Boxes (2ft × 4ft × 7ft) | 67 $ft^3$ | "SWB" |
| Metal Sandia boxes (4ft × 4ft × 7ft) | 112 $ft^3$ | "SAN box" |
| Plywood Strong Outer Package<br>• Full (4ft × 4ft × 7ft)<br>• Half (2ft × 4ft × 7ft) | <br>112 $ft^3$<br>56 $ft^3$ | <br>"full crate"<br>"half crate |
| Metal Boxes<br>• M – Box (48 in × 48 in × 84 in)<br>• V – Box (62 in × 62 in × 50 in)<br>• I - Box (88 in × 47 in × 40 in) | <br>111 $ft^3$<br>95 $ft^3$<br>95 $ft^3$ | <br>"metal box"<br>"metal box"<br>"metal box" |
| IP-2 Metal Box<br>• Full (4ft × 4ft × 7ft)<br>• Half (2ft × 4ft × 7ft) | <br>67 $ft^3$<br>112 $ft^3$ | <br>"metal box" , "IP2, full"<br>"metal box" , "IP2, half" |
| Pipe Overpack Containers (6 in × 25 in, 12 in × 25 in) | 0.43 $ft^3$, 1.7 $ft^3$ | "POC", |
| Atomic Materials Rail Transport Yard Cargo Containers<br>• 8ft × 8ft × 20ft<br>• 8ft × 8ft × 40ft) | <br>1280 $ft^3$<br>2560 $ft^3$ | <br>"ATMX", " yard cargo"<br>"ATMX", " yard cargo" |
| 275 gallon and 10,000 gallon Waste Storage Tanks. | 37 $ft^3$ , 1537 $ft^3$ | "waste storage tank" |

Note: **On-site sampling transfer containers and HEPA filter shipping containers are also utilized during RMRS Waste Management Facilities operations.**

### 1.3.3 Waste Management Facility Confinement Enclosures

Waste management repackaging and treatment (RT) activities, as defined in Section 1.4.4, are typically performed in unique special confinement enclosures that control contamination and assure safe operation as described below. Waste types typically processed in the operating confinement enclosures are also presented. Ancillary supporting systems and features necessary for safe operation are described.

Building Confinement

The waste management facility and its structure protect the operations inside and the workers performing the operations from inclement weather conditions. Waste management facilities meet at least PC-2 wind and seismic loading design requirements.

Repackaging and Treatment Confinement Area

An RT, or building, confinement area separates the RT operation from other operations in the waste facility. The RT confinement is assumed to protect the RT operation from building debris generated by a beyond-PC-2 seismic event.

Repackaging and Treatment Confinement Enclosure

An RT confinement enclosure can be used for both LL/LLM and TRU/TRM waste. An RT confinement enclosure is an enclosure within the RT confinement area where non-conforming wastes are removed and repackaged via placement into drums, metal boxes, or SWBs for return to waste storage or shipment offsite. Inspection and sampling of LL/LLM and TRU/TRM waste can be performed during RT operations. Various types of non-thermal LLM waste treatment (e.g., stabilization, neutralization, etc) to Land Disposal Restriction (LDR) requirements may be performed. TRU/TRM metal waste container filter vent replacement can be performed. Types of RT confinement enclosures, per waste type usage, include:

Glovebox

A glovebox inside the RT confinement provides an enclosure where both LL/LLM and TRU/TRM waste is repackaged. Currently, only LL/LLM waste can be treated in a glovebox. Site closure planning does include/allow onsite treatment of TRM waste. A controlled HEPA-filtered airflow in the glovebox acts to mitigate contamination releases. A glovebox has an integral fire suppression system in addition to the waste building's fire suppression system.

Contamination-Cell

A contamination-cell (C-cell) inside the RT confinement provides an enclosure where waste is repackaged or treated. A controlled airflow in the C-cell acts to mitigate any contamination releases. A C-cell does not necessarily have an integrated fire suppression system and may rely on the waste building's fire suppression system. Only LL/LLM waste may be repackaged or treated in a C-cell.

Perma-Con

A Perma-Con is a modular confinement enclosure constructed of interlocking metal panels where waste containers are opened, prepared for repackaging, repackaged, and waste can be treated to LDR requirements. A Perma-Con is equipped with HEPA filtration to mitigate contamination releases. A Perma-Con is used for LL/LLM waste only. Perma-Cons typically do not have fire suppression systems and typically are not protected by building fire suppression systems.

Glovebag

A glovebag is a plastic bag attachment to allow contamination confinement during the various RT operations (*e.g.*, inspection, sorting, sampling, repackaging, treatment, etc.) using 55-gallon drums.

Ventilation System

The RT confinement will have a ventilation system that ensures that all air leaving the repackaging and treatment confinement enclosure passes through at least one (1) stage of HEPA filters. However, the single stage HEPA is not tested to a $10^{-3}$ removal efficiency for LLW applications. The ventilation system for the repackaging confinement provides two (2) barriers for the control of loose contamination. The confinement enclosures provide the primary barrier while the repackaging confinement provides the secondary barrier.

Fire Suppression and Alarm Annunciation System

The RT confinement, where present, will be connected to the building's automatic building fire suppression system. Additionally, an automatic confinement enclosure fire suppression system with a fire alarm annunciation signal is provided for some RT confinements.

### 1.3.4 RMRS Waste Management Facilities

Waste management facilities consist of three construction types: substantial, medium, and light (or none). Facilities with substantial construction are made of concrete, cinder block, etc. Facilities with medium construction include structural steel framing with sheet metal siding and roof. Medium construction facilities include Butler type buildings and cargo containers. Facilities with light construction (or none) include tents, wood frame buildings, and open storage areas with no protective structure at all. For the purposes of this NSTR, RMRS waste management facilities are categorized by construction type as shown in Table 1-2. Facility construction type affects accident scenario damage ratio (DR) determinations for external event and natural phenomena hazards. A brief synopsis of RMRS waste management facilities and their major activities is provided in subsequent sections. The location of RMRS waste management facilities at RFETS is presented in Figure 1-1.

**Table 1-2** Facility Construction

| WASTE MANAGEMENT FACILITY | CONSTRUCTION TYPE |
|---|---|
| 440 | Medium |
| 460 | Medium |
| 569 | Medium |
| 664 | Medium |
| 666 | Medium |
| 750 Pad | Light |
| 904 Pad | Light |
| 906 | Medium |
| 991 | Substantial |
| RCRA Units 1, 10, 13, 15A*, & 18.04 | Medium |
| RCRA Units 15A* and 18.03 | None (open storage) |
| RCRA Unit 24 | Light |

* RCRA Unit 15A is comprised of cargo containers and open storage, therefore both categories medium and none apply.

Building 440 – Waste Storage

Building 440 is a corrugated metal building with corrugated metal roof constructed on a concrete slab on grade. Building 440 comprises 39,000 $ft^2$ of which 26,000 $ft^2$ is used for waste management operations. Building 440 is a waste storage facility for transuranic (TRU) waste, transuranic mixed (TRM) waste, low-level waste (LL), low-level mixed (LLM), and hazardous (HAZ) waste with attendant LLW and TRM repackaging capability. LLW and LLMW are staged for offsite shipment and disposal. Field radiography may be conducted to characterize waste stored in Building 440. Building 440 is a RCRA-permitted storage area.

Building 460 – TRU Waste Storage

***Reserved pending decision on usage as a waste storage facility.***

Building 569 – Waste Assay

Building 569 is a single-story, pre-engineered metal building on concrete foundations with 7,620 square feet of floor space. Building 569 houses a Passive-Active Crate Counter (PACC) to non-destructive assay crates of radioactive LL, LLM, TRU, and TRM waste to determine the amount of radionuclides present. A Passive-Active Drum Counter (PADC) and a Low Specific Activity Counter (LOSAC) are utilized to non-destructive assay the same waste types packaged in drums. A Real-Time Radiography (RTR) unit is used to examine the contents



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of residue and residue-mixed drums, TRU/TRM, and LL/LLM waste drums without opening them. Building 569 is a RCRA-permitted storage area.

Building 664 Complex – Waste Storage and Shipment

The Building 664 Complex' mission consists of waste container RTR, NDA, storage and staging, waste inspection, waste certification, and truck loading and shipment of LL, LLM, TRU, and TRM wastes. LL waste drums are stored in cargo containers in the fenced 300,000 $ft^2$ 664 Facility yard. LL, LLM, TRU and TRM waste is stored inside Building 664. The building, including the high bay and bridge crane section, comprises approximately 20,000 $ft^2$. Building 668 is a 5,000 $ft^2$ wood frame shed with fiberglass and transite wall panels. Building 664A is a 5,000 $ft^2$ wood frame, metal-sided and roofed portable, modular office building. Two NDA trailers are parked within the fenced area and are used to assay waste drums prior to shipment to the Waste Isolation Pilot Plant (WIPP) for disposal. Real-Time Radiography (RTR) is also conducted at Building 664 to radiologically characterize waste.

The offsite transportation modes are TRUPACT II for TRU and TRM waste and common carrier for LL and LLM waste. Drums are limited to a radioactive material inventory of 200 grams of plutonium per drum and 1,225 grams equivalent per POC. Building 664 is a RCRA-permitted storage facility.

Building 666 – TSCA Waste Storage Facility

Building 666 is a 1,200 $ft^2$ prefabricated metal frame building with metal exterior walls and roof. The building rests on a concrete slab on grade. The building is used solely for TSCA waste storage; there is no office area. There are five associated cargo containers located adjacent to Building 666 to augment the storage capacity of the Building 666. A sixth cargo container is used to store empty drums, personal protective equipment (PPE), and spill absorbent (Floor Dri). Four types of Toxic Substance Control Act (TSCA) waste are stored and managed at Building 666 prior to shipment offsite for treatment/disposal: (a) non-radioactive, non-friable asbestos waste, (b) radioactively-contaminated asbestos waste, (c) waste contaminated with PCBs, and (d) radioactive waste contaminated with PCBs.

750/904 Pads – Waste Storage

The 750 and 904 Pads are asphalt-paved areas that are appropriately sloped for drainage. Each pad has approximately 6-to-12 inch high berms around the perimeter to collect runoff from precipitation. The 750 and 904 Pads are used for storage of LL, LLM, and HAZ waste, and for waste sampling and repackaging operations for LL and LLM waste. Large enclosures called Perma-Cons are used for LL/LLM waste sampling and repackaging activities. Tents 2 and 12 on the 750 Pad are also used for storage of TRU and TRM waste inside pipe overpack containers (POCs). Field radiography is conducted to characterize waste stored at the 750 and 904 Pads. The 750/904 Pads are RCRA-permitted storage areas.

Building 906 – Waste Storage

Building 906 is a single-story, 25,000 $ft^2$ steel frame, metal-clad structure with reinforced concrete footings. Building 906 is used for the storage of LL, LLM, and HAZ waste. Wastes containing free liquid are not stored in Building 906. Field radiography may be conducted in Building 906 to determine the contents of waste containers. Building 906 is a RCRA-permitted storage area.

Building 991 Complex – Waste Storage

Building 991 is a 32,659 $ft^2$ single-story reinforced concrete with metal-on-metal framing. The Building 991 Complex includes support Buildings 985, 996, 997, 998, and 999. These underground, reinforced concrete buildings comprise 20,940 $ft^2$ and are connected to Building 991 via tunnels. Buildings 984 and 985 are aboveground, metal sheds used for drum crushing and housing the filter plenum. Building 991 is used for the receipt, storage, transfer and shipment of LL, TRU, and Category I/II Special Nuclear Material (SNM) waste. SNM waste will be shipped on Safe, Secure, Transports (SSTs).

RCRA Storage Units –Hazardous Waste Storage

RCRA storage units 1, 10, 13, 15A, 18.03, 18.04, and 24 are used for the temporary storage of HAZ, LL, LLM, and TRM waste (Note: RCRA Unit 15 B is managed under the 904 Pad described above). The storage units consist of cargo containers, buildings, and fenced outdoor pad areas. No drums are stored outside cargo containers or buildings. For each storage unit, the maximum total capacity, maximum liquid capacity, and allowable waste types are defined by the Site RCRA Part B Permit. Routine non-breachment operations performed in the RCRA Units include drum overpack (no leaks), drum and box movements, Canberra NDA services, hoisting and rigging, housekeeping, staging, and on-site and off-site shipping. Routine breachment operations include drum pumping, overpacking (with leaks), sampling, re-packaging and consolidation, returning samples, lab packing, characterization and verification, drum venting and de-heading, and spill clean-up.

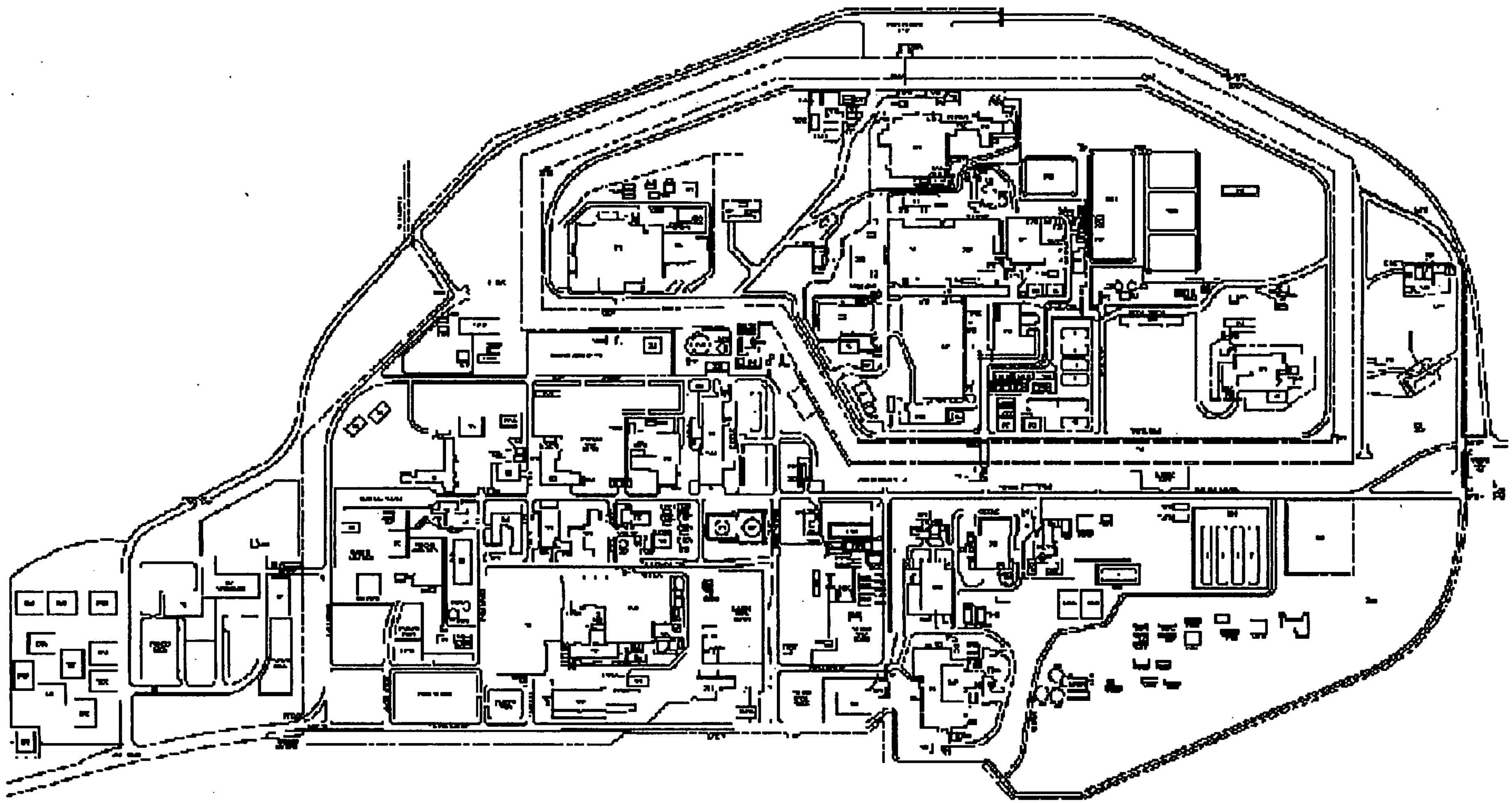

Figure 1-1 Location of RMRS Waste Management Facilities at RFETS

## 1.4 WASTE MANAGEMENT ACTIVITIES

This section lists and describes the RMRS waste management activities performed at the Site and covered by this Nuclear Safety Technical Report. The waste management activities are grouped by combining common sub-activities (*e.g.*, storage, characterization, repackaging, etc.) and waste type (*e.g.*, HAZ, LL, and TRM), and whether primary confinement is breached during normal operating conditions (*e.g.*, repackaging requires breaching the waste container while storage does not). This section of the NSTR is intended to provide a fundamental understanding of the facility processes and activities subsequently analyzed in Chapter 2, *Hazard and Accident Analysis*. Each waste management activity "group" is presented generally as an activity module with associated sub-activities. The waste activity modules are shown in Table 1-3.

**Table 1-3** RMRS Waste Management Activity Modules

| ACTIVITY MODULE | ACRONYM |
|---|---|
| Waste Storage and Handling | SH |
| Waste Characterization – Chemical | CC |
| Waste Characterization – Radiological | CR |
| Waste Repackaging and Treatment | RT |
| Waste Generation | GN |
| Routine Activities | RA |

Table 1-4 lists the waste management facility activity modules and sub-activities and indicates the waste management facility(ies) where each activity is currently being performed. Figure 1-2 depicts those waste activity modules pertinent to each facility, the waste management interfaces and interactions between the facilities, and the flow of waste, by waste type, to offsite storage, treatment, and disposal sites in support of Site Closure. Sections 1.4.1 through 1.4.6 detail each of the above major waste activity modules and associated sub-activities. A general description is provided followed by a more detailed description of the sub-activities. These waste management activity descriptions provide the reader with information helpful to understanding the scope of the safety analysis and derivation of a consolidated control set (not included as part of this NSTR).



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**Table 1-4** RMRS Waste Management Facility/Activity Matrix

| ACTIVITY MODULE | WASTE MANAGEMENT FACILITY | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 440 | 569 | 664 Complex | 666 | 750/904 | 906 | 991 Complex | RCRA Units |
| **Waste Storage and Handling (SH) §1.4.1** | | | | | | | | |
| • Receipt, Handling, Storage, and Staging of LL, LLM Waste §1.4.1.1 | √ | √ | √ | √ | √ | √ | √ | √ |
| • Receipt, Handling, Storage, and Staging of HAZ and TSCA Waste §1.4.1.2 | √ | | √ | √ | | | | √ |
| • Receipt, Handling, Storage, and Staging of TRU and TRM Waste §1.4.1.3 | √ | √ | √ | | √ | √ | √ | √ |
| • Receipt, Handling, Storage, and Staging of Category I/II Special Nuclear Material §1.4.1.4 | | | | | | | √ | |
| **Waste Characterization – Chemical (CC) §1.4.2** | | | | | | | | |
| • Inspection, Characterization, Sampling and Analysis of HAZ, LL, LLM, TRU, TRM Waste §1.4.2.1 | √ | | | | √ | | √ | |
| • Inspection, Characterization, Sampling and Analysis of TRM Waste §1.4.2.2 | √ | | | | | | | |
| • Headspace Gas Sampling and Analysis and Gas Generation Testing of TRU, and TRM Waste §1.4.2.3 | √ | | | | | | √ | |
| **Waste Characterization – Radiological (CR) §1.4.3** | | | | | | | | |
| • Waste Box and Drum Counting §1.4.3.1 | √ | √ | √ | | | | √ | |
| • Field Radiography §1.4.3.2 | √ | | √ | | √ | | | |
| • Real-Time Radiography §1.4.3.3 | | √ | √ | | | | √ | |

**Table 1-4** RMRS Waste Management Facility/Activity Matrix

| ACTIVITY MODULE | WASTE MANAGEMENT FACILITY | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 440 | 569 | 664 Complex | 666 | 750/904 | 906 | 991 Complex | RCRA Units |
| • Non-Destructive Assay §1.4.3.4 | | √ | | | | | | √ |
| • Decommissioning In-Situ Plutonium Inventory Monitoring §1.4.3.5 | | | | | | | √ | |
| **Waste Repackaging and Treatment (RT) §1.4.4** | | | | | | | | |
| • Inspection, Sampling, and Repackaging of LL, LLM, TRU, and TRM Waste §1.4.5.1 | √ | | √ | | √ | | | √ |
| • Treatment of LLM Waste, including Excess Chemicals §1.4.5.2 | √ | | √ | | √ | | √ | |
| • Waste Container Filter Vent Testing and Replacement §1.4.5 3 | √ | | | | | | | |
| **Waste Generation (GN) §1.4.5** | | | | | | | | |
| | √ | √ | √ | √ | √ | √ | √ | √ |
| **Routine Activities (RA) §1.4.6** | | | | | | | | |
| • Construction §1.4.6.1 | √ | √ | √ | √ | √ | √ | √ | √ |
| • Maintenance §1.4.6.2 | √ | √ | √ | √ | √ | √ | √ | √ |
| • Surveillance §1.4.6.3 | √ | √ | √ | √ | √ | √ | √ | √ |
| • Other Routine Activities §1.4.6.4 | √ | √ | √ | √ | √ | √ | √ | √ |



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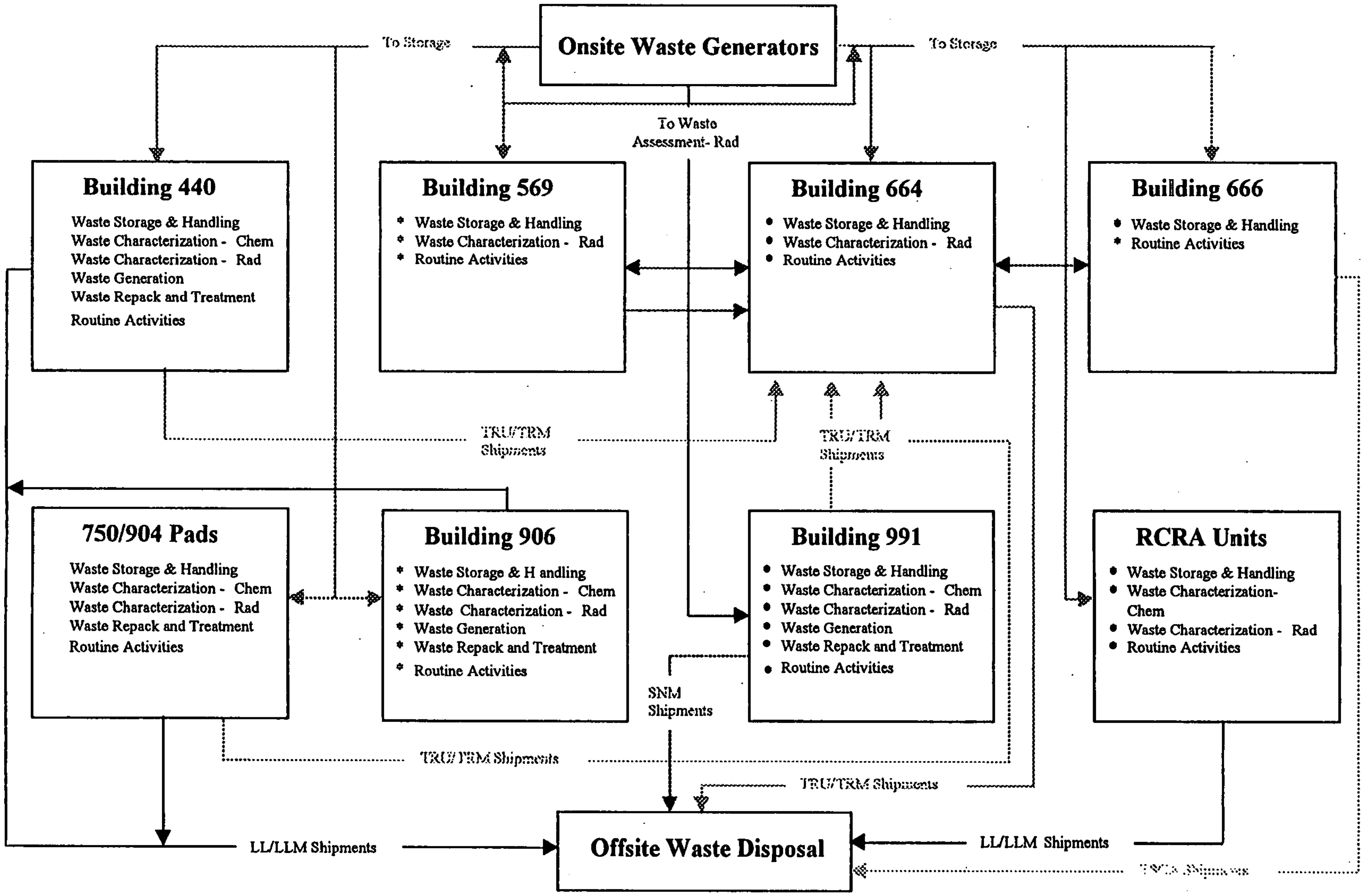


**Figure 1-2** RMRS Waste Management Facility/Activity Interaction at RFETS



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### 1.4.1 Waste Storage and Handling (SH)

The waste storage and handling module involves all activities associated with receiving, handling, storage, and staging of HAZ, TSCA, LL, LLM, TRU, and TRM waste, and Category I/II SNM. Waste transfer between onsite facilities and the shipment of waste offsite is addressed in the Site Safety Analysis Report (Site SAR) hazard and accident analyses and is not addressed in this NSTR.

All physical waste container receiving, handling, staging, and storage activities in support of the related waste management activity modules Waste Characterization - Chemical (CC), Waste Characterization - Radiological (CR), Waste Repackaging and Treatment (RT), and Waste Generation (GN) is enveloped by this module.

Primary waste container packaging is not breached under normal operating conditions in the Storage and Handling activity module. The hazards and accident analyses specific to waste receiving, handling, staging, and storage are presented and evaluated in Sections 6.2.1 and 8.

#### 1.4.1.1 Receipt, Handling, Storage, and Staging of LL and LLM Waste

This activity encompasses the following sub-activities:

- *LL and LLM Waste Receipt*: waste container receipt from onsite waste generators, waste container receiving inspection (on-site shipping specifications and Department of Transportation [DOT] specifications), waste container identification, waste container labeling and placarding,

- *LL and LLM Waste Handling:* movement of waste containers within a facility via manual conveyance or via forklift, drum huggers, portable loading docks, or bridge crane to loading dock, staging, and storage locations.

- *LL and LLM Waste Storage*: RCRA regulatory compliance, waste container stacking, waste container banding, waste container inspection and reporting, and waste container overpacking.

- *LL and LLM Waste Staging*: prepare and stage waste containers for transport. Staging involves limited-duration storage of a discrete number of waste containers in support of other waste operations activities such as Waste Characterization-Radiological and Waste Repackaging and Treatment. Staging activities also support waste transportation activities (onsite transfer or offsite shipment) addressed in the Site SAR. Staging sub-activities include waste inspections, waste certification (includes compliance with waste-packaging requirements, waste form requirements, waste limits, documentation requirements), and radiological vehicle monitoring, radioactive contamination surveys, waste container staging, and waste container loading via forklift or crane onto transport vehicles.

Note: LL and TRU waste is not placed in the same vehicle due to different offsite shipping destinations. Also, LL and LLM waste is not shipped in the same vehicle due to segregation requirements at the disposal facilities. TRU and TRM wastes may be transported in the same TRUPACT II container if they belong to the same shipping category.

#### 1.4.1.2 Receipt, Handling, Storage, and Staging of HAZ and TSCA Waste

This activity encompasses the following sub-activities:

- *HAZ and TSCA Waste Receipt*: waste container receipt from onsite waste generators, waste container receiving inspection (on-site shipping specifications and Department of Transportation [DOT] specifications), waste container identification, waste container labeling and placarding,

- *HAZ and TSCA Waste Handling*: movement of waste containers within a facility via manual conveyance or via forklift, drum huggers, portable loading docks, or bridge crane, to loading dock, staging, and storage locations.

- *HAZ and TSCA Waste Storage*: RCRA and TSCA regulatory compliance (as required), waste container stacking, waste container banding, waste container inspection and reporting, and waste container overpacking.

- *HAZ and TSCA Waste Staging*: prepare and stage waste containers for transport. Staging involves limited-duration storage of a discrete number of waste containers in support of other waste operations activities such as Waste Characterization-Radiological and Waste Repackaging, Treatment, and Disposition. Staging activities also support waste transportation activities (onsite transfer or offsite shipment) addressed in the Site SAR. Staging sub-activities include waste inspections, waste certification (includes compliance with waste-packaging requirements, waste form requirements, waste limits, documentation requirements), and radiological vehicle monitoring, radioactive contamination surveys, waste container staging, and waste container loading via forklift or crane onto transport vehicles.

#### 1.4.1.3 Receipt, Handling, Storage, and Staging of TRU and TRM Waste

This activity encompasses the following sub-activities:

- *TRU and TRM Waste Receipt*: waste container receipt from onsite waste generators, waste container receiving inspection (on-site shipping specifications or Department of Transportation [DOT] specifications), waste container identification, waste container labeling and placarding,

- *TRU and TRM Waste Handling*: movement of waste containers within a facility via manual conveyance or via forklift, drum huggers, portable loading docks, mobile TRUPACT II, loading dock, or bridge crane, to loading dock, staging, and storage locations.



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- *TRU and TRM Waste Storage*: RCRA regulatory compliance (as required), waste container stacking, waste container banding, waste container inspection and reporting, and waste container overpacking.

- *TRU and TRM Waste Staging*: prepare and stage waste containers for transport. Staging involves limited-duration storage of a discrete number of waste containers in support of other waste operations activities such as Waste Characterization-Radiological and Waste Repackaging, Treatment, and Disposition. Staging activities also support waste transportation activities (onsite transfer or offsite shipment) addressed in the Site SAR. Staging sub-activities include waste inspections, waste certification (includes compliance with waste-packaging requirements, waste form requirements, waste limits, documentation requirements), and radiological vehicle monitoring, radioactive contamination surveys, waste container staging, and waste container loading via forklift or crane onto transport vehicles.

Note: LL and TRU waste is not placed in the same vehicle due to different offsite shipping destinations. Also, LL and LLM waste is not shipped in the same vehicle due to segregation requirements at the disposal facilities. TRU and TRM wastes may be transported in the same TRUPACT II container if they belong to the same shipping category.

**1.4.1.4** Receipt, Handling, Storage, and Staging of Category I/II SNM

This activity encompasses the following sub-activities:

- *Category I/II SNM Receipt*: waste container receipt from onsite generators, container receiving inspection (on-site shipping specifications and Department of Transportation [DOT] specifications), container identification, container labeling and placarding,

- *Category I/II SNM Handling*: movement of containers within a facility via manual conveyance or via forklift, drum huggers, portable loading docks, or bridge crane, to loading dock, and staging locations.

- *Category I/II SNM Staging*: prepare and stage containers for transport. Staging involves limited-duration storage of a discrete number of containers in support of other waste operations activities such as Waste Characterization-Radiological and Waste Repackaging and Treatment. Staging activities also support waste transportation activities (onsite transfer or offsite shipment) addressed in the Site SAR. Staging sub-activities include inspections, certification (includes compliance with packaging requirements, form requirements, radiological limits, documentation requirements), and radiological vehicle monitoring, radioactive contamination surveys, container staging, and container loading via forklift or crane onto transport vehicles.

### 1.4.2 Waste Characterization – Chemical (CC)

The Waste Characterization – Chemical activity module involves only the physical and chemical inspection, characterization, and sampling and analysis of HAZ, LL, LLM, TRU, and

TRM waste. This module also involves the sub-activities headspace gas sampling and gas generation testing of TRU and TRM waste.

Primary waste container packaging is breached under normal operating conditions in the Waste Characterization-Chemical activity module. The hazards and accident analyses specific to Waste Characterization – Chemical are presented and evaluated in Sections 6.2.2 and 9.

Note: waste container receiving, handling, staging, and storage activities in support of this module are addressed in the Waste Storage and Handling module.

**1.4.2.1** Inspection, Characterization, Sampling and Analysis of HAZ, LL, and LLM Waste

This activity encompasses the following sub-activities:

- *Waste Container Content Inspection*: waste container identification, radiation surveys, attaching a drum glovebag/baghouse to the waste container, waste container opening, and visual inspection of waste form.

- *Waste Characterization*: radiation surveys, attaching a drum glovebag/ baghouse to the waste container, waste container opening, visual inspection of waste form to verify process knowledge and waste traveler documentation of container contents.

- *Waste Sampling and Analysis*: radiation surveys, attaching a drum glovebag/ baghouse to the waste container, waste container opening, physical sampling (via scoop, core, grab, etc. sampling), and analysis of samples of waste.

**1.4.2.2** Inspection, Characterization, Sampling and Analysis of TRU and TRM Waste

This activity encompasses the following sub-activities:

- *Waste Container Content Inspection*: waste container identification, radiation surveys, attaching a drum glovebag/baghouse to the waste container, waste container opening, and visual inspection of waste form.

- *Waste Characterization*: radiation surveys, attaching a drum glovebag/baghouse to the waste container, waste container opening, visual inspection of waste form to verify process knowledge and waste traveler documentation of container contents.

- *Waste Sampling and Analysis*: radiation surveys, attaching a drum glovebag/baghouse to the waste container, waste container opening, physical sampling (*e.g.*, scoop, core, grab, etc. sampling), and analysis of samples of waste.

#### 1.4.2.3 Headspace Gas Sampling and Analysis and Gas Generation Testing of TRU and TRM Waste

This activity encompasses the following sub-activities necessary to sample TRU and TRM waste for the existence of possible explosive gases:

- *Headspace Gas Sampling*: installation of the headspace gas sampling unit, waste container identification, drum removal from storage or staging array, waste container remote opening in dedicated headspace gas sampling unit, gas sampling extraction and analysis, drum return to storage or staging array.
- *Gas Generation Testing*: installation of the gas generation testing unit (including electric heating blankets), radiation surveys, drum removal from storage or staging array, waste container remote opening in dedicated gas generation testing unit, gas sampling extraction and analysis, drum return to storage or staging array.

### 1.4.3 Waste Characterization – Radiological (CR)

The Waste Characterization – Radiological activity module involves only the radiological inspection, characterization, and sampling and analysis of LL, LLM, TRU, and TRM waste via the various non-destructive assay (NDA) techniques described in this section.

Primary waste container packaging is not breached under normal operating conditions in the Waste Characterization – Radiological module. The hazards and accident analyses specific to Waste Characterization – Radiological are presented and evaluated in Sections 6.2.3 and 10.

Note: waste container receiving, handling, staging, and storage activities in support of this module are addressed in the Waste Storage and Handling module. Repackaging activities are addressed in the Repackaging and Treatment module.

#### 1.4.3.1 Waste Box and Drum Counting

Waste box and drum Counting is a test method to determine box and drum radioactive material content. The contents of waste drums are non-destructively assayed using the Passive Active Drum Counter (PADC), the Low Specific Activity Counter (LOSAC), or the Segmented Gamma Scan Drum Counter (SGSDC). The contents of waste boxes are non-destructively assayed using the Passive Active Crate Counter (PACC).

This activity encompasses the following sub-activities:

- *Waste Box and Drum Counting*: identify LL, LLM, TRU, and, TRM waste containers, receive waste drums and waste boxes, stage for non-destructive assay and/or radiography operations, assay waste containers, temporarily store containers that meet applicable packaging criteria in the building or moved to the loading dock and transported to another building for storage pending off-site shipment, stage containers that do not meet packaging criteria or that exhibit physical damage upon receipt for transfer to another building to be repacked.

1.4.3.2 Field Radiography

Field radiography is a non-destructive testing method conducted to characterize waste, verify IDC mixture requirements, verify packaging requirements, and determine whether free liquids are present. Sealed radiological sources are used during X-ray field radiography activities.

This activity encompasses the following sub-activities:

- *Field Radiography*: identify LL, LLM, TRU, TRM waste containers, stage drums/boxes for field radiography, placement into RTR unit, assay drums/boxes, analyze data, non-conforming waste, e.g. free liquids, removal, stage and return waste to storage/generating facility for corrective processing, return compliant drums/boxes to staging or storage area.

1.4.3.3 Real-Time Radiography (RTR)

Real Time Radiography (RTR) is a non-destructive test method, which allows an operator to characterize waste, verify IDC mixture requirements, verify packaging requirements, and determine whether free liquids are present. X-rays and an imaging device are used to generate real-time images that are viewed on a video monitor by a certified operator to verify conditions such as amount of free liquid and whether or not a container is pressurized. An audio/visual record is stored on videotape to create a permanent record of the inspected waste container contents.

This activity encompasses the following sub-activities:

- *RTR*: identify LL, LLM, TRU, TRM waste containers, stage drums/boxes for real-time radiography, placement into RTR unit, assay drums/boxes, analyze data, non-conforming waste, e.g. free liquids, removal, staging and return waste to storage/generating facility for corrective processing, prepare/process Non-Conformance Report (NCR), return compliant drums/boxes to staging or storage area.

1.4.3.4 Mobile NDA – Canberra Trailers

Two mobile Canberra NDA trailers are positioned inside the fenced yard of Building 664. One Canberra trailer contains an IQ3 Gamma Scanner system used to perform qualitative and quantitative analysis characterization of "suspect TRU" waste drums. A second Canberra trailer contains Segmented Gamma Scanner and an automated passive neutron (PN) counter system. Both trailers contain micro Ci to milli Ci sealed sources to provide correction for absorption in the waste matrix and to aid in determining waste densities. The mobile NDA Canberra Trailers are used to certify TRU waste to allow shipment of the waste to the WIPP site for disposal.

The Canberra $Q^2$ Mobile Waste Assay System at the RCRA Units will be used to perform NDA services for packaged low-level (LL) waste and low-level mixed (LLM) waste. NDA results are used to facilitate offsite treatment and disposal of the LL and LLM waste and assure measured quantities of radiation meet Department of Transportation (DOT) requirements.

This activity encompasses the following sub-activities:

- *NDA*: identify LL, LLM, TRU, TRM waste containers, stage drums/boxes for field radiography, place drums onto powered NDA conveyor for counting, assay drums/boxes, analyze data, after scanning/counting, place drums back onto containers powered NDA conveyor and return drums to storage.

1.4.3.5 Decommissioning In-Situ Plutonium Inventory Monitoring (DISPIM)

The Decommissioning In-Situ Plutonium Inventory Monitoring (DISPIM™) system employs both passive neutron counting and gamma spectrometry techniques in its non-destructive measurement. The neutron technique enables the $^{240}Pu$ equivalent mass and location of fissile material to be determined. Gamma spectrometry allows the specific Pu and U isotopes and the relative masses to be calculated. The DISPIM™ is a mobile unit used to determine the plutonium and fissile mass in waste drums, boxes, and gloveboxes.

This activity encompasses the following sub-activities:

- *DISPIM*: stage drums/boxes or glovebox for DISPIM, deploy DISPIM around target drums/boxes or glovebox, assay drums/boxes or glovebox, analyze data, return drums/boxes or glovebox to staging or storage area.

### 1.4.4 Waste Repackaging and Treatment (RT)

The Waste Repackaging and Treatment activity module involves only the inspection, sorting, sampling, and repackaging of LL, LLM, TRU, and TRM waste containers. LLM waste treatment (including Excess or Waste Chemicals), and TRU and TRM waste container filter vent testing and replacement are also included in this activity module.

Primary waste container packaging is breached under normal operating conditions in the Waste Repackaging and Treatment activity module. The hazards and accident analyses specific to Waste Repackaging and Treatment are presented and evaluated in Sections 6.2.4 and 11.

Note: waste container receiving, handling, staging, and storage activities in support of this module are addressed in the Waste Storage and Handling module.

This activity encompasses the following sub-activities:

1.4.4.1 Inspection, Sampling, and Repackaging of LL, LLM, TRU, and TRM Waste

Waste Repackaging activities are conducted to identify and segregate potentially incompatible waste chemicals that may be located within the same container, to verify conformance with disposal site waste acceptance criteria (WAC), or to support other waste management efforts, such as shipment for offsite disposal. This activity encompasses the following sub-activities:



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- *Repackaging of LL, LLM, TRU, and TRM Waste*: identify waste containers, stage and transport drums to repackaging facility, prepare drums for repackaging inside containment structure, transfer drums into approved repackaging containment area, e.g., glovebox or Perma-Con, visual verify the integrity of the packaging or container and contents, repack drums, segregate non-conforming waste items and bag out to placement in drums, metal waste boxes, or SWBs, crush used drums as required, stage and return repackaged drums to storage facility.

**1.4.4.2** Treatment of LLM Waste

Waste Treatment activities are conducted to neutralize and stabilize LLM waste, including waste or excess chemicals, that are no longer to be used as part of another building Baseline or Mission Program Activity.

This activity encompasses the following sub-activities:

- *Treatment of LLM Waste*: identify LLM waste containers, stage drums for transport to treatment facility, prepare drums for treatment, stage drums into treatment confinement enclosure (*e.g.*, C-cell, glovebox, or Perma-Con), treat waste via neutralization and/or stabilization, crush used drums as required, stage and return treated waste to storage facility (see also 1.4.1, Waste Storage and Handling, 1.4.2, Waste Characterization – Chemical, and Section 1.4.3, Waste Characterization – Radiological activity modules).

**1.4.4.3** Waste Container Filter Vent Testing and Replacement

TRU and TRM metal waste container filter vents are tested and replaced to prevent gas buildup resulting in potential explosion and fire accident scenarios.

This activity encompasses the following sub-activities:

- *TRU and TRM Waste Container Filter Vent Testing and Replacement*: inspect metal waste containers for the presence of unobstructed filter vent, stage containers for transport to approved confinement area (*e.g.*, containment cell, baghouse, glovebox, or Perma-Con, etc.), replace filter vent, stage containers for transport to storage facility.

### 1.4.5 Waste Generation (GN)

The waste generation module involves only the generation of primary HAZ, TSCA, LL, LLM, TRU, or TRM waste during incidental spill cleanup activities, decontamination, decommissioning, deactivation, and demolition (D4) operations, environmental restoration (ER) operations, and waste management repackaging operations. Generation of secondary LLM waste is also possible during onsite LLM waste treatment activities.

Waste containers are packaged and filled as a normal operation within the Waste Generation module. The hazards and accident analyses specific to Waste Generation are presented and evaluated in Sections 6.2.5 and 12.

Note: waste container receiving, handling, staging, and storage activities in support of this module are addressed in the Waste Storage and Handling module. Waste treatment activities are addressed in the Waste Repackaging and Treatment module. Routine waste management, D4, and ER operations activities responsible for the generation of waste, *e.g.*, construction, maintenance, etc., is addressed in the Routine Activities module.

This activity encompasses the following sub-activities:

- *HAZ, TSCA, LL, LLM, TRU, or TRM Waste Generation*: generate waste incidental to spill cleanup, decommissioning and decontamination activities, environmental cleanup activities, waste management repackaging operations, and onsite waste treatment activities, characterize, sample and analyze waste to determine treatment and disposal options, transfer generated waste to storage pending either onsite treatment or offsite shipment for treatment and/or disposal.

### 1.4.6 Routine Activities (RA)

The Routine Activities module involves only those activities generally necessary to support day-to-day conduct of facility activities e.g., records management, document control, security and access control, general housekeeping required for control of combustibles, hazardous materials, radiological materials.

Primary waste container packaging is not breached under normal operating conditions in the Routine Activities module. The hazards and accident analyses specific to Routine Activities are presented and evaluated in Sections 6.2.6 and 13.

Note: waste container receiving, handling, staging, and storage activities in support of this module are addressed in the Waste Storage and Handling module. Waste management, D4, and ER operations that generate waste are addressed in the Waste Generation module.

This activity encompasses the following sub-activities:

#### 1.4.6.1 Construction

Construction includes Integrated Work Plan Process (IWCP) activities including upgrades to various waste management facility structures, systems, and components (SSCs), modification of various SSCs, removal of fixed SSCs from the building, addition of various SSCs. Also included are those IWCP activities in support of D4 and ER operations, e.g., construction of containment structures, treatment systems, etc.

This activity encompasses the following sub-activities:

- *Construction*: implement Integrated Work Control Process (IWCP) upgrades of various waste management facility SSCs, modification of various SSCs, removal of fixed SSCs from the building, and addition of various SSCs, construction of D4 and ER containment structures, treatment systems, etc.

**1.4.6.2** Maintenance

Maintenance, testing and repair of various waste management facility SSCs can occur anywhere inside or outside of the waste operations facility. SSCs potentially involved with this activity include the heating, ventilating and air conditioning (HVAC) system, and the fire suppression, detection, and alarm, and utilities systems. Maintenance activities in support of facility D4 and ER operations is also included in this activity.

This activity encompasses the following sub-activities:

- *Maintenance*: maintenance, testing and repair of various waste management facility SSCs can occur anywhere inside or outside of the waste operations facility. SSCs potentially involved with this activity include the heating, ventilating and air conditioning (HVAC) system, and the fire suppression, detection, and alarm, and utilities systems. Maintenance includes D4 and ER operations.

**1.4.6.3** Surveillance

Surveillance predominately consists of system and equipment surveillances specified for LCO systems and other components; surveillance of other SSCs as specified in ACs; routine facility operator rounds, including maintenance of logs and records; security force tours, response actions; and programmatic inspections and audits (e.g., environmental compliance assessments, fire protection and radiological protection surveys, and audits from federal, state and local authorities). Surveillance activities include waste management facilities, and D4 and ER operations.

This activity encompasses the following sub-activities:

- *Surveillance*: The surveillance aspect of this activity predominately consists of system and equipment surveillances specified for LCO systems and other components; surveillance of other SSCs as specified in ACs; routine facility operator rounds, including maintenance of logs and records; security force tours, response actions; and programmatic inspections and audits (e.g., environmental compliance assessments, fire protection and radiological protection surveys, and audits from federal, state and local authorities). Surveillance activities occur in waste management facilities, and D4 and ER operations.

**1.4.6.4** Other Activities

Other routine activities are those activities generally necessary to support day-to-day conduct of waste management, D4 and ER operations activities, e.g., records management, document control, security and access control, general housekeeping required for control of combustibles, hazardous materials, radiological materials.

This activity encompasses the following sub-activities:

- *Other Routine Activities*: day-to-day conduct of facility activities e.g., records management, document control, security and access control, general housekeeping required for control of combustibles, hazardous materials, radiological materials, utilities maintenance to support safety systems that maintain the safety envelope or habitability, e.g., water; ventilation; electric power; sanitary waste; and compressed air, maintaining emergency response capability. Non-destructive testing may also be routinely performed to support. D4 and ER operations activities.

# 2. HAZARD AND ACCIDENT ANALYSIS INTRODUCTION

Various hazards are currently present in RMRS waste management facilities and will be discussed in this chapter. The following waste management facilities are addressed in this NSTR: 440, 460, 569, 664, 666, 750 Pad, 904 Pad, 906, 991, and RCRA Storage Units 1, 10, 13 (Building 884), 15A, 18.03, 18.04 and 24 (Building 964). Building 460 is included in the list because it has been selected as a potential candidate for conversion into a TRU waste storage facility. If converted, it would be the closest waste management facility to the Site boundary at 1,200 meters. The RMRS waste management facilities addressed in this NSTR are hereafter referred to as simply "waste management facilities."

Category I and II SNM is only found in Department of Transportation (DOT) approved, Type B shipping containers, which are currently only received by Building 991 and staged in the facility in preparation for off-site shipment.

Radioactive waste materials are primarily stored in 55-gallon drums meeting on-site shipping specifications and/or DOT specifications; however, waste management facilities may receive and store Transuranic Package Transporter II (TRUPACT II) Standard Waste Boxes (SWBs) and DOT-7A, Type A Metal Waste Boxes. The 55-gallon waste drums may be standard Transuranic (TRU) waste drums or Pipe Overpack Containers (POCs). In addition, wooden Low-Level Waste (LLW) boxes may be received and stored in various waste management facilities

This NSTR addresses the identification and the evaluation of the hazards associated with the RMRS waste management primary mission: movement, storage, characterization (including inspection, sampling, and analysis), and disposition (including repackaging, treatment, and staging for off-site shipment) of hazardous radioactive materials and waste. Transfer of hazardous and radioactive materials and waste between on-site facilities and off-site transportation are addressed in the Site SAR (Ref. 2). This NSTR evaluates the consequences of postulated accident scenarios leading to radiological and/or toxicological (chemical) releases that may be caused by operational, external, and natural phenomena-related events. The evaluated potential consequences and risks (frequency times consequence) to workers, both immediate and collocated, and the public, as represented by the maximum [exposed] off-site individual (MOI), are presented. Preventive and/or mitigative features (structures, systems, and components (SSCs) or elements of administrative programs) credited to reduce risk by lowering postulated accident frequencies and/or by reducing receptor consequences have also been identified for inclusion into a consolidated control set, *Waste Management Facilities Technical Safety Requirements* (Ref. 1) which will be appended to each RMRS Hazard Category 2 and 3 Nuclear Facility AB document. In addition, discussions addressing hazard identification, hazard evaluation, accident analysis methodology, and risk classification methodology are presented. Appendix A of this NSTR provides the supporting calculations for the analyses that follow.

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# 3. REQUIREMENTS

The standards, regulations, and DOE Orders reviewed in support of the development of this NSTR are listed below. Only portions of the listed documents are relevant to the development of this NSTR namely, those that cover hazard identification and evaluation, Safety Analysis, risk classification, and operational controls. A comprehensive listing of standards and regulations addressing occupational safety and environmental protection is not provided.

- *Facility Safety*, DOE Order 420.1 (Ref. 4):

  The Order addresses operational controls dealing with Natural Phenomena Hazards Mitigation, Fire Protection, General Design Criteria, and Criticality Safety.

- *Nuclear Safety Analysis Reports*, DOE Order 5480.23 (Ref. 5):

  This Order specifies the requirement for FSAR preparation for nuclear facilities. The Order also specifies that the FSAR should include identification and evaluation of both nuclear and non-nuclear hazards.

- *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE Standard 3009-94 (Ref. 6):

  The Standard addresses hazard identification/evaluation and Safety Analysis by providing guidance on the analysis techniques and level of detail.

- *Guidance for the Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, DOE Standard 3011-94 (Ref. 7):

  This Standard addresses hazard identification and evaluation by providing guidance on performing a Preliminary Hazards Analysis (PHA). The Standard also addresses risk classification by defining candidate consequence evaluation guidelines and risk categories for postulated accident scenarios.

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# 4. METHODOLOGY

## 4.1 OVERVIEW OF THE HAZARDS AND ACCIDENT ANALYSIS PROCESS

The Safety Analysis presented in this NSTR uses a PHA technique to identify and evaluate the hazards and postulated accident scenarios associated with the operation of RMRS Waste Management Facilities. This technique begins by identifying existing or potential hazards (*e.g.*, radioactive sources, radioactive wastes, chemicals, or non-material hazards (*e.g.*, thermal energy sources, pressure sources, electrical energy sources)) in terms of quantity, form, packaging, location, affected or affecting activities, and recognized preventive and/or mitigative features (SSCs or elements of administrative programs) associated with the hazard.

Based on the information developed by the PHA and presented in the hazards description table, determinations are made on whether further evaluation of specific hazards are necessary. In general, no further evaluation is performed on those hazards that: (1) could be characterized as Standard Industrial Hazards and (2) have limited impact on postulated accident initiation frequency, accident mitigation, and accident consequences. Industrial hazards that could only lead to occupational injuries or illnesses are addressed by the Site Industrial Safety program as discussed in the *Safety Management Programs* section/chapter of individual AB documents.

For those hazards determined to require further evaluation, a hazards evaluation matrix was developed relating identified waste management activities with corresponding hazards in order to derive postulated accident scenarios. For each postulated accident scenario, the hazards evaluation matrix presents: (1) scenario descriptive information including the corresponding activity and hazard leading to the scenario; (2) a categorization of the accident type; and (3) a qualitative assessment of scenario frequency, consequences, and risk class assuming identified, inherent preventive and mitigative features are in place. Based on the information presented in the hazards evaluation matrix, postulated accident scenarios of higher risk are selected as candidate, bounding accident scenarios for further, detailed evaluation. The bounding accident scenarios are representative of the waste management facilities and operations at RFETS. Bounding accident scenarios are identified for each of those postulated accident scenarios that are not carried forward for further analysis. Any inherent preventive and/or mitigative features associated with the bounded scenarios that resulted in the scenario being low risk are assigned to the bounding scenarios in order to carry forward all credited preventive and mitigative features.

In some cases, a bounding accident scenario qualitative frequency assessment may be further refined using event tree methodology displaying accident progression and impact of identified preventive and/or mitigative features. In all cases, the bounding accident scenario qualitative consequence assessment is refined using Site consequence evaluation tools. Quantitative estimates of scenario initial [respirable] source terms (ISTs) are determined based on: (1) estimated damage ratios (DRs) associated with the postulated accident scenario; (2) bounding material-at-risk (MAR) estimates associated with analyzed activities and expected radioactive or chemical containers; and (3) airborne respirable release fractions (ARRFs) taken from *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* DOE-HDBK-3010-94 (Ref. 8), for radioactive material release scenarios. Scenario consequences are determined using: (1) the ISTs; (2) estimates of applicable, facility leakpath factors; (3) Site atmospheric dispersion values; (4) receptor breathing rates; and (5) dose conversion factors for radioactive material releases. Risk classifications of the bounding accident scenarios are then determined using a qualitative binning methodology based on the refined accident frequency and the newly determined quantitative estimates of accident consequence.

In those cases where a bounding accident scenario was determined to present a high risk, further evaluations were performed to identify any additional preventive or mitigative features that could be used to lower the scenario risk. These evaluations are presented in the Control Set Vulnerability section of each accident scenario. The adequacy of and vulnerability associated with credited preventive and mitigative features were presented for each accident scenario.

Risk dominant accident scenarios (*i.e.*, scenarios presenting the highest risk following the crediting of preventive and mitigative features) will be addressed in individual facility AB documents incorporating the results of the discussion in the Control Set Vulnerability sections of this NSTR.

## 4.2 RISK CLASSIFICATION METHODOLOGY

The risks associated with postulated accident scenarios identified in the hazard evaluation tables or evaluated as bounding accident scenarios, as discussed in the previous section, can be categorized according to a combination of the scenario frequencies and consequences, as shown in Table 1. The categorization bins accident scenario risk into one of four risk classes. For the purpose of this document, risks associated with Risk Class I accident scenarios are considered *major*, risks associated with Risk Class II scenarios are *serious*, Risk Class III accident scenario risks are *marginal*, and Risk Class IV accident scenario risks are considered *negligible*. In addition, Risk Class I and II accident scenarios are considered to be *high-risk* scenarios, and Risk Class III and IV scenarios are considered to be *low-risk* scenarios. The risk class associated with each of the accident scenarios identified and evaluated in the remainder of NSTR-006-99 was determined based on the Table 4-1 categorization scheme.

**Table 4-1** Risk Classes – Frequency Versus Consequence

| | FREQUENCY OF OCCURRENCE | | |
|---|---|---|---|
| CONSEQUENCE | EXTREMELY UNLIKELY $<10^{-4}$ events/year | UNLIKELY between $10^{-4}$ and $10^{-2}$ events/year | ANTICIPATED $>10^{-2}$ events/year |
| HIGH | II | I | I |
| MODERATE | III | II | I |
| LOW | IV | III | III |

As stated earlier, inherent preventive and mitigative features required to be in place in order to maintain those Risk Class III and IV accident scenarios identified in the hazard evaluation tables as low-risk scenarios are carried forward with corresponding bounding accident scenarios. Postulated accident scenarios identified in the hazard evaluation tables as Risk Class I or II scenarios are evaluated further to determine if any preventive or mitigative features exist, which if implemented, could reduce the scenario risk to a Risk Class III or IV category. The collection of the credited preventive and mitigative features associated with initial and bounding scenario evaluations are carried forward into the development of a consolidated control set, *Waste Management Facilities Technical Safety Requirements* (Ref. **Error! Bookmark not defined.**), which will be appended to each RMRS Hazard Category 2 and 3 Nuclear Waste Management Facility AB document.

For those postulated accident scenarios that are evaluated to be Risk Class I or II scenarios and for which no preventive or mitigative features can be identified to reduce the scenario risk class, discussions related to the acceptability of the high-risk scenarios are provided in individual AB documents and not discussed in this NSTR.

The application of Table 4-1 requires frequency bin and consequence bin assignments. Frequency bin assignments are in accordance with DOE-STD-3011-94; *i.e.*, events more frequent than $10^{-2}$ per year are classified as *anticipated*, those with frequencies between $10^{-4}$ per year and $10^{-2}$ per year are classified as *unlikely*, and those less frequent than $10^{-4}$ per year are classified as *extremely unlikely*. These frequency bin terms and assignments are consistent with DOE-STD-3009-94 qualitative likelihood classifications. Low-likelihood, high-risk scenarios are identified and discussed in those instances where the risk potential of the postulated accident scenario is judged to be significant relative to other credible scenarios. Estimates of scenario frequency are generally qualitative but may be quantitatively defined, in some cases, with the use of event trees. In cases where sufficient qualitative arguments for lower accident scenario frequencies cannot be made, the scenario is classified as *anticipated*.

### 4.2.1 Radiological Risk

Radiological dose consequence evaluations are performed using the following equation:

$$\text{Dose} = \text{MAR} * \text{DR} * \text{ARRF} * \text{LPF} * \chi/Q * \text{BR} * \text{DCF} / \text{PDC}$$

where
- MAR is the radioactive material-at-risk (in grams, varies with scenario);
- DR is the MAR damage ratio (varies with scenario);
- ARRF is the airborne respirable release fraction (varies with form of radioactive material and scenario);
- LPF is the facility leakpath factor (initially set to 1.0, varies with scenario);
- $\chi/Q$ is the atmospheric dispersion factor (in $s/m^3$, varies with receptor and scenario);
- BR is the receptor breathing rate (in $m^3/s$, set for heavy activity);
- DCF is the radiological material dose conversion factor (in rem/gram, varies with material type); and
- PDC is the plume duration correction factor (varies with scenario).



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The PDC value is used for accident scenarios with a duration longer than 10 minutes (*e.g.*, large fires). The PDC value is used to modify the atmospheric dispersion value to correct for plume meander during the scenario. The formula used for determining plume meander for longer duration releases is as follows:

$$PDC = (\text{plume duration in minutes / time base})^n$$

where the time base is 10 minutes; "n" has a value of 0.2 if the plume duration is less than or equal to 60 minutes; otherwise, "n" has a value of 0.25.

The atmospheric dispersion factors ($\chi/Q$ values) used in the radiological dose consequence evaluations are based on the receptor (*i.e.*, distance from the point of release), the type of accident scenario (*i.e.*, non-lofted plume or lofted plume), and modeling assumptions (*i.e.*, use of conservative 95$^{th}$ percentile values or median (50$^{th}$ percentile) values). In most cases, the atmospheric dispersion factors represent 95$^{th}$ percentile $\chi/Q$ values developed from an analysis of actual Site weather data. Two receptors are identified for analysis: (1) the public as represented by the MOI and (2) the CW.

The shortest distances from waste management facilities to the MOI located at the Site boundary were determined using tables found in RFP-5098, *Safety Analysis and Risk Assessment Handbook* (SARAH) (Ref. 9) and are shown in Table 4-2. For the purpose of evaluating scenario consequences in this NSTR, a representative shortest distance to the Site boundary (*i.e.*, 1,200 meters from Building 460) and the furthest distance to the Site Boundary (*i.e.*, 2,367 meters from Building 991) are used. Use of the representative shortest distance provides bounding consequence values that can be used for comparison in the Unreviewed Safety Question Determination (USQD) process. Facilities further from the Site boundary would have consequences of decreasing magnitude. As in the case of the CW, if the maximum $\chi/Q$ value is realized at a distance greater than the MOI distance as a result of accident scenario modeling assumptions, the higher $\chi/Q$ value is used in the analysis. For example, the maximum, 95$^{th}$ percentile $\chi/Q$ value for the MOI for a lofted plume occurs at a distance of 4,020 meters since the plume is "lofted" over the person at the Site boundary, as discussed in RFP-4965, *Reference Computations of Public Dose and Cancer Risk from Airborne Releases of Uranium and Class W Plutonium* (Ref. 10).

The CW distance from the point of release, for most cases, has been set at 100 meters. This approach departs from the distance of 600 meters, which is suggested for use by DOE-STD-3011-94 (Ref. 7). If the maximum $\chi/Q$ value is realized at a distance greater than 100 meters as a result of accident scenario modeling assumptions, the higher $\chi/Q$ value is used in the analysis. For example, the maximum, median $\chi/Q$ value for the CW for a lofted plume occurs at a distance greater than 100 meters since the plume is "lofted" over the CW at 100 meters. This overall approach for analyzing CW radiological dose consequences is more conservative than the DOE Standard approach and is appropriate for the following reasons: (1) many CWs are closer to a waste management facility than 600 meters due to the proximity of other Site facilities and the compactness of the Site; (2) the minimum distance used in formulations supporting the Gaussian plume atmospheric dispersion model is 100 meters; and (3) distances associated with evaluated maximum $\chi/Q$ values occurring beyond 100 meters are encompassed by the Site boundary.

**Table 4-2** Least Distances to Site Boundary

| FACILITY | LEAST DISTANCE TO SITE BOUNDARY (METERS) |
|---|---|
| 440 | 1,243 |
| 460 | 1,200 |
| 569 | 1,796 |
| 664 | 1,453 |
| 666 | 1,627 |
| 750 Pad | 2,066 |
| 904 Pad | 2,091 |
| 906 | 2,082 |
| 991 | 2,367 |
| RCRA Units 13 and 24 | 1,812 |
| RCRA Units 1, 10, 15A, 18.03, and 18.04 | 1,636 |

The term "immediate worker" (IW) is used to describe the individual who could be located in close proximity to the postulated accident scenario release location or who could be located within the waste management facility impacted by the postulated accident. For IW consequences, a qualitative judgment of acute radiological effects is made. It does not include latent cancer effects, per the guidance provided in DOE-STD-3009-94 (Ref. 6). Scenario related effects (*e.g.*, burns from fires, injuries from energetic events) are discussed in the accident scenario summaries but are not included in the determination of the scenario risk class (i.e., only radiological and toxicological doses are considered in risk class determinations).

Radiological dose consequences corresponding to the High, Moderate, and Low consequence bins identified in Table 4-1 are defined by the comparison criteria developed in DOE-STD-3011-94 and shown in Table 4-3. Radiological dose consequence bin thresholds for the MOI and CW are defined in terms of 50-year, Committed Effective Dose Equivalent (CEDE) radiological doses. As stated above, radiological dose consequences for the IW are determined qualitatively; therefore, the radiological dose consequence bin thresholds for the IW are also defined qualitatively.

**Table 4-3** Radiological Dose Consequence Bin Thresholds

| CONSEQUENCE | MOI DOSE CONSEQUENCE BIN THRESHOLD | CW DOSE CONSEQUENCE BIN THRESHOLD | IW CONSEQUENCE |
|---|---|---|---|
| HIGH | dose > 5 rem | dose >25 rem | prompt death |
| MODERATE | 5 rem ≥ dose > 0.1 rem | 25 rem ≥ dose > 0.5 rem | serious injury |
| LOW | 0.1 rem ≥ dose | 0.5 rem ≥ dose | < MODERATE |



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Radiological doses are calculated using the *Radiological Dose Template* (Ref. 11) and are presented in the *Accident Consequences* section of each evaluated scenario.

### 4.2.2 Chemical And Other Hazardous Material Risk

Toxicological consequence evaluations for postulated accident scenarios involving chemicals and other hazardous materials are determined using a combination of qualitative and quantitative evaluation techniques as discussed below. The receptors identified for analysis are: (1) the MOI; (2) the CW; and (3) the IW. The definition and location of the receptors of interest are the same as for the radiological consequence evaluations discussed in Section 4.2.1, *Radiological Risk*.

Hazardous materials can exist throughout a facility and may be in various forms. In support of the determination of hazardous material risks, hazardous material inventories are defined in four general categories: (1) hazardous materials in waste; (2) process chemicals; (3) bulk or product chemicals; and (4) in situ hazardous materials.

The hazardous materials in waste category includes Resource Conservation and Recovery Act (RCRA) containerized wastes, Toxic Substances Control Act (TSCA) containerized wastes, and non-RCRA/non-TSCA hazardous material containerized waste. The containers utilized for holding hazardous materials include, in part, 55-gallon drums, metal standard waste boxes, and wooden waste crates. The hazardous materials, in many cases, may be located in the same containers as radioactive materials. Information regarding containerized waste may be obtained from the Site-wide Waste and Environmental Management System (WEMS) database or equivalent facility databases. These databases contain characterization information for each waste container including: waste type; container type; Item Description Code (IDC) or Waste Form code (WFC) designation; assigned Environmental Protection Agency (EPA) waste codes; and waste compatibility codes.

The process chemicals category includes chemicals that have been introduced into processes that were suspended or never activated or have been introduced into current operating processes. Any chemical holdup in solution piping is included in this category. Process chemicals, in some cases, may contain radioactive materials. Information about process chemicals is generally determined by interviews with facility personnel.

The product or bulk chemical category includes chemicals that are planned for use and are currently being stored in the facility. Bulk chemicals are not contaminated with radioactive materials. Information about bulk chemicals may be obtained from the Site-wide Integrated Chemical Management System (ICMS) database or equivalent facility databases.

The in situ hazardous materials category includes hazardous materials that exist in the facility as part of structure (*e.g.*, lead-base paints located on walls and floors; asbestos containing ceiling panels, floor tiles, or walls; polychlorinated-biphenyl (PCB) containing equipment like fluorescent lighting or transformers). In general, in situ hazardous materials are fixed in place and, in some cases, may be contaminated with radioactive materials.

Hazardous chemicals and other materials in the facility that are identified as being in one of the four hazardous material categories are screened against: (1) the Threshold Planning Quantity (TPQ) values listed in *List of Regulated Substances and Thresholds for Accidental Release Prevention*, 40 CFR 355 (Ref. 12); (2) the Threshold Quantity (TQ) values listed in *Process Safety Management (PSM) of Highly Hazardous Chemicals*, 29 CFR 1910.119, (Ref. 13) and *Risk Management Programs for Chemical Accidental Release Prevention*, 40 CFR 68, (Ref. 14); and (3) the Reportable Quantity (RQ) values listed in *List of Hazardous Substances and Reportable Quantities*, 40 CFR 302 (Ref. 15). Hazardous materials potentially found in waste management facilities are listed in Appendix D of the SARAH (Ref. 9) along with TPQ, TQ, and RQ values. If the quantity of the hazardous material in the facility is below TPQ, TQ, and RQ values, the material does not require further evaluation.

For hazardous materials that do not have TPQ or TQ values but have RQ values and the quantity of material in the facility exceeds the RQ value, qualitative arguments dealing with dispersibility and programmatic controls associated with the hazard are used to complete the hazard evaluation. These types of hazardous materials, in general, only pose threats to the IW and/or the environment and not to the CW or the public.

For hazardous materials with facility quantities in excess of specified TPQ or TQ values, a quantitative evaluation of accidental releases of the material is performed. Determinations are made of chemical concentrations at the CW and MOI receptor locations using Site-accepted chemical dispersion modeling tools as identified in the SARAH (Ref. 9).

For IW consequences, a qualitative judgment of acute toxicological effects is made. Scenario related effects (*e.g.*, burns from fires, injuries from energetic events) are discussed in the accident scenario summaries but are not included in the determination of the scenario risk class.

Toxicological consequences corresponding to the High, Moderate, and Low consequence bins identified in Table 4-1 are defined by the comparison criteria developed in DOE-STD-3011-94 and shown in Table 4-4. Toxicological consequence bin thresholds for the MOI and CW are defined in terms of *Emergency Response Planning Guideline* (ERPG) values, published by the American Industrial Hygiene Association (Ref. 16). These guidelines include a set of three numbers (ERPG-1, ERPG-2, and ERPG-3) that quantify the air concentrations for each chemical, corresponding to *low, moderate,* and *severe* health effects in humans exposed to the chemical concentration for up to one hour. The "up to one hour" guideline in the definition of ERPGs is interpreted to mean "peak 15-minute average" by the Energy Facility Contractors Group (EFCOG) Non-radiological Hazardous Materials Safety Analysis Subgroup. Concentrations of the various chemicals are calculated at the receptor locations and compared to the assigned ERPG values (or alternative values) in order to determine a consequence bin assignment in accordance with Table 4-4. The *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities* (Ref. 17) discusses alternative standards for cases where no ERPG value has been assigned. As stated above, toxicological consequences for the IW are determined qualitatively; therefore, the toxicological consequence bin thresholds for the IW are defined qualitatively.

**Table 4-4** Chemical Toxicological Consequence Bin Thresholds

| CONSEQUENCE | MOI CONCENTRATION CONSEQUENCE BIN THRESHOLD | CW CONCENTRATION CONSEQUENCE BIN THRESHOLD | IW CONSEQUENCE |
|---|---|---|---|
| HIGH | concentration > ERPG-2 | concentration > ERPG-3 | prompt death |
| MODERATE | not applicable | not applicable | serious injury |
| LOW | concentration ≤ ERPG-2 | concentration ≤ ERPG-3 | < MODERATE |

# 5. HAZARD IDENTIFICATION AND DESCRIPTION

This section identifies the radioactive materials and other hazardous materials present in waste management facilities as well as identifying hazards and energy sources that may contribute to a radiological and/or toxicological release. Initial hazard identification for waste management facilities was accomplished by reviewing radiological and other hazardous material inventories currently in the facilities, by interviewing facility personnel for additional hazardous materials that may be present during the conduct of waste management activities, by performing facility walkdown inspections, and by reviewing previously DOE approved waste management facility AB documents.

A standardized general hazard identification checklist presented in the SARAH was used to identify the general hazard categories present in waste management facilities. The SARAH describes the checklist and its application. The hazards specific to waste management facilities and operations are identified in the general hazard checklist shown in Table 5-1. Of the 13 hazard categories appearing on the general checklist, 12 hazards were found to be present in one or more waste management facilities.

The general hazards identified in Table 5-1 are summarized in more detail in Table 5-4. The hazard description in the table and the corresponding text provides sufficient detail to justify the classification of identified hazards as Standard Industrial Hazards (*i.e.*, hazards that only lead to occupational injuries or illnesses and that have limited impact on postulated accident initiation frequency, accident mitigation, and accident consequences). Standard Industrial Hazards are considered to be sufficiently controlled by the Safety Management Programs (SMPs) listed in the *Safety Management Programs* section/chapter of individual AB documents and are not analyzed further. Hazards that have not been classified as Standard Industrial Hazards are carried forward into the Safety Analysis.

**Table 5-1** Waste Management Facility General Hazard Identification Checklist

| HAZARD | HAZARD DEFINITION | YES/NO |
|---|---|---|
| 1. High Voltage | Electrical systems or components that have voltages greater than 600 V, including AC electric power distribution systems from Site power. | Yes |
| 2. Explosive Substances | Explosive devices or chemicals that are being prepared or used in explosive devices (*e.g.*, blasting caps, squibs, dynamite) as designated in 49 CFR 173.50 (Ref. 18); does not include potentially explosive gases or chemicals. | No |
| 3. Direct Radiation Sources | Sources that produce ionizing radiation at a known level (*e.g.*, X-ray machines, waste assay equipment, accelerators, sealed sources). | Yes |
| 4. Radioactive Materials | Radioactive materials that are dispersible (*i.e.*, require low energy for release); does not include sealed sources or nontransferable contamination. | Yes |
| 5. Thermal Energy | Hazards that are capable of producing burns, starting fires, causing undesired chemical reactions, or producing hazardous vapors, including hot surfaces. | Yes |
| 6. Pressure Sources | High-pressure systems (liquid or gas) that are capable of rupturing, producing damaging missiles, or hazardous material dispersal energy, including compressed air used as a facility utility and standard compressed gas bottles. | Yes |



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**Table 5-1** Waste Management Facility General Hazard Identification Checklist

| HAZARD | HAZARD DEFINITION | YES/NO |
|---|---|---|
| 7. Kinetic Energy | Moving or rotating equipment that is capable of breaching hazardous material containers or producing damaging missiles. | Yes |
| 8. Potential Energy | Systems, components, or situations that have stored energy; including chemical systems (*e.g.*, large battery banks), electrical systems (*e.g.*, large capacitor banks); or mechanical systems or situations (*e.g.*, large elevated masses, raised waste containers). | Yes |
| 9. Hazardous Chemicals or Materials | Chemicals or materials that are considered toxic, noxious, or otherwise hazardous (*e.g.*, RCRA listed, TSCA listed). | Yes |
| 10. Inadequate Ventilation | Areas or rooms that are susceptible to low or inadequate ventilation where flammable gases, hazardous vapors, or asphyxiants may accumulate (*e.g.*, confined spaces). | Yes |
| 11. Material Handling | Operations that involve continuous handling of materials (*e.g.*, waste container receipt and shipment). | Yes |
| 12. Unknown or Unmarked Materials | Materials or chemicals that are of unknown nature (*e.g.*, unmarked containers). | Yes |
| 13. Other Hazards | Hazard or concern that does not fit into a specific hazard category; (*e.g.*, areas with high combustible loading, areas with high levels of contamination, areas particularly susceptible to natural phenomena, shock sensitive chemicals, explosive gases). | Yes |

Table 5-4 lists the twelve general hazards identified in waste management facilities and specifies more detail for each hazard. General hazard characterization information dealing with hazard attributes such as description, form, and packaging are provided in the table and further discussed in the corresponding hazard sub-section text.

Some hazards are only present for specific activities or situations (*e.g.*, kinetic energy associated with forklifts is only applicable when the forklifts are being used). The table identifies those activity modules from Section 1.4, *Waste Management Activities*, of this NSTR to which a specific hazard may be applicable. Applicable activity modules are defined as a set of activities that can create or interact with specific identified hazard/energy source. Acronyms for activity modules that are used throughout the remainder of the Safety Analysis are defined in Table 1-1.

Two general classes of hazards may exist in waste management facilities: (1) dispersible hazards (*e.g.*, radioactive material, hazardous chemicals) that must be contained or confined to protect receptors; and (2) hazards that can potentially act on the containment or confinement of other hazards (*e.g.*, moving equipment, combustibles). The hazardous components of non-dispersible hazards that can impact the IW (*e.g.*, high voltage electricity, moving equipment) but cannot impact the CW or the public are considered to be addressed by Site programs and are not the focus of the hazard evaluation process. This hazard evaluation process presumes that hazardous, dispersible materials are contained in packages that may be susceptible to breach by mechanical, chemical, or thermal means. The process also presumes that the dominant dispersible hazards deal with radioactive materials and will only address chemical hazards in cases where significant quantities, relative to specified TQs or TPQs, are available for release.

Table 5-4 and the explanatory text identify a set of candidate general protective features that can be used to reduce the risk associated with the specified hazard for those hazards that are determined to be Standard Industrial Hazards. The approach used in the determination of protective features associated with a hazard focuses on how the hazard potentially interacts mechanically, chemically, or thermally with the containment or confinement barriers for hazardous materials. In addition, a set of worker safety protective features is identified for each hazard characterized as a Standard Industrial Hazard, which will not be further evaluated. For IW safety, three levels of protection are always addressed, even if no protection exists for the level: (1) physical barriers around or dealing with the hazard that can protect the worker (*e.g.*, fences, shielding); (2) general classes of protective equipment for the worker (*e.g.*, protective clothing, breathing devices); and (3) administrative imposed requirements to protect the worker (*e.g.*, postings, lockout/tagout). The set of protective features for IW protection is not intended to be a complete listing. Rather, protective features covering those aspects of the hazard that are considered to place the IW at most risk are listed.

Each of the specified features that is credited in making the determination that the hazard is a Standard Industrial Hazard will have a corresponding Site SMP identified as the credited program. Acronyms corresponding to Site SMPs that are used in the following tables are defined in Table 5-2. For hazards that are carried forward in the Safety Analysis, the entry under the "Credited Protective Features" column of Table 5-4 is ADB (Analyzed in Detail Below).

An indication of the general types of accident scenarios associated with Non-Standard Industrial Hazards is provided in the "Remarks" column of Table 5-4. For each hazard that is to be carried forward in the Safety Analysis, potential accident scenarios involving the hazard or caused by the hazard are identified. Seven general types of accident scenarios are used to characterize the spectrum of analyzed events. The seven accident scenario types are listed and defined in Table 5-3. The table addresses the accident types in terms of events involving radioactive materials but the general accident scenario types could also be applied to other hazardous materials (*e.g.*, chemicals).



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**Table 5-2** Acronyms for the Site Safety Management Programs

| ACRONYM | SAFETY MANAGEMENT PROGRAM TITLE |
|---|---|
| ORG | Organization and Management |
| CONFIG | Configuration Management |
| COOP | Conduct of Operations |
| CRIT | Criticality Safety |
| EP | Emergency Preparedness |
| FIRE | Fire Protection |
| HMP | Hazardous Material Protection |
| INS | Industrial Safety |
| NUC | Nuclear Safety |
| OR | Occurrence Reporting |
| PROC | Procedures |
| QA | Quality Assurance |
| RAD | Radiation Protection |
| TRAIN | Training |
| TS&M | Testing, Surveillance, and Maintenance |
| WMEP | Waste Management and Environmental Protection |
| WORK | Work Control |

**Table 5-3** General Types of Accident Scenarios in Safety Analysis

| SCENARIO TYPE | GENERAL ACCIDENT SCENARIO DESCRIPTION |
|---|---|
| Material Fire | This accident scenario type is used to cover fires caused by pyrophoric radioactive material exposures to air (*i.e.*, container breach). Waste management facilities will handle containers containing pyrophoric radioactive metals as part of the SH activity and as required to support the conduct of the CC, CR, and RT activities (*e.g.*, movement of containers prior to performing work). This type of fire is distinguished from the "Facility Fire" scenario type due to the initiating event mechanism differences (*i.e.*, more spill-like than fire-like). |
| Facility Fire | This accident scenario type is used to address fires occurring within the waste management facility that can be caused or exacerbated by the conduct of the SH, CC, CR, RT, GN, and RA activities (*e.g.*, mixing incompatible chemicals, errors while performing hot work, introduction of combustible material). |
| Spill | This accident scenario type is used to cover spills of confined radioactive material as the result of radioactive material container drops during the handling and storage of the containers under the conduct of the SH activities, as required to support the conduct of the CC, CR, RT, and GN activities (*e.g.*, movement of materials prior to performing work), and due to inadvertent contact with containers during the conduct of the RA activities (*e.g.*, vehicle contact with containers during movement of "non-hazardous" materials for construction). |
| Puncture | This accident scenario type is used to cover punctures of containers containing radioactive material as the result of radioactive material container contact with forklift tines during the handling of the containers under the conduct of the SH activities, as required to support the conduct of the CC, CR, and RT, activities (*e.g.*, movement of materials by forklift prior to performing work), and due to inadvertent contact with containers during the conduct of the RA activities (*e.g.*, forklift contact with containers during movement of "non-hazardous" materials for construction). This type of spill is distinguished from the "Spill" scenario type to draw attention to the spill resistance of the Type B shipping containers and the POC versus the Type B shipping containers and the POC susceptibility to puncture events. |
| Container Explosion | This accident scenario type is used to cover waste container hydrogen explosions as a result of the handling of the containers under the conduct of the SH activity, as required to support the conduct of the CC, CR, RT, and GN activities (*e.g.*, movement of containers prior to performing work), and due to inadvertent contact with containers during the conduct of the RA activities (*e.g.*, vehicle contact with containers during movement of "non-hazardous" materials for construction). This type of explosion is distinguished from the "Facility Explosion" scenario type due to the initiating event mechanism differences (*i.e.*, container movement can lead to container explosion where the introduction of flammable gas is needed for facility explosion). |
| Facility Explosion | This accident scenario type is used to address explosions occurring within the waste management facility that can be caused by the conduct of the RA activities (*e.g.*, errors while using propane) and can impact radioactive material containers associated with the SH, CC, CR, GN, and RT activities. |



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**Table 5-3** General Types of Accident Scenarios in Safety Analysis

| SCENARIO TYPE | GENERAL ACCIDENT SCENARIO DESCRIPTION |
|---|---|
| Criticality | This accident scenario type is used to cover radioactive material criticalities as a result of the rearrangement of containers under the conduct of the SH activities and as required to support the conduct of the CC, CR, GN, RT, and RA activities (*e.g.*, movement of containers prior to performing work), and as a result of other accident scenarios initiated by any of the activities. |

## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **1. HIGH VOLTAGE:** | | | | | |
| A. 13.8kV Transformers | *e.g.*, Standard transformers for converting Site power (13.8kV) to facility power (480V) | Fenced enclosure | RA | HAZARD CONTROL<br>• Current configuration control<br>• Combustible control<br><br>IW PROTECTION<br>• Fenced area, insulated enclosure<br>• Insulated clothing & equipment<br>• Work control, postings, training, lockout/tagout | **Standard Industrial Hazard**<br>Transformers located away from any waste storage locations;<br>No identified mechanism for interaction with radioactive materials.<br><br>Credited SMPs: CONFIG; FIRE; INS; PROC; TRAIN; and WORK<br><br>Lower voltage electric power is considered in Safety Analysis as fire initiators (see THERMAL ENERGY). |
| **3. DIRECT RADIATION SOURCES:** | | | | | |
| A. Sealed Sources | Site standard instrument calibration sources | Site standard sealed source packaging | SH, CR, RA, RT | HAZARD CONTROL<br>• Source package<br><br>IW PROTECTION<br>• Shielding<br>• Dosimetry, leaded clothing<br>• Source inspection, source package quality, postings, work control, ALARA, training, source use evaluation, source control | **Standard Industrial Hazard**<br>Used for instrument calibration including portable equipment;<br>Sealed sources, while containing radioactive material, pose no risk to CW or public due to packaging.<br><br>Credited SMPs: ORG; INS; PROC; QA; RAD; TRAIN; TS&M; and WORK |
| B. Radiation Generating Equipment | *e.g.*, Real Time Radiography units, drum and crate counters, portable iridium-192 source | Shielded containment | CR | HAZARD CONTROL<br>• Current configuration control<br><br>IW PROTECTION<br>• Device shielding<br>• Interlocks<br>• Dosimetry<br>• Device inspection, postings, work control, training, device control | **Standard Industrial Hazard**<br>Used for Non Destructive Testing (NDT);<br>Radiation generating devices, while producing radiation, poses no risk to CW or public due to separation distances.<br><br>Credited SMPs: ORG; CONFIG; INS; PROC; RAD; TRAIN; and WORK |



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## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **3. DIRECT RADIATION SOURCES:** (continued) | | | | | |
| C. Radiation From Stored/Staged Waste Containers | *e.g.*, Radioactive contamination on waste | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box | SH, CC, CR, GN, RT | HAZARD CONTROL<br>• Waste containers<br>• Current configuration control<br><br>IW PROTECTION<br>• Shielding<br>• Protective clothing and equipment, dosimetry<br>• Maintenance work evaluation, area surveys, radiation work permits, work control, postings, ALARA, training | **Standard Industrial Hazard**<br>Stored/staged containers that contain radioactive material pose small risk to CW and no risk to the public due to packaging and separation distance.<br><br>Credited SMPs: ORG; CONFIG; INS; PROC; RAD; TRAIN; and WORK. |
| **4. RADIOACTIVE MATERIALS:** | | | | | |
| A. Category I and II SNM | Uranium, plutonium metals, or plutonium oxides | Approved DOT Type B shipping containers | SH | ADB | Considered in Safety Analysis as radioactive material source for material fire, facility fire, spill, puncture, facility explosion, and criticality events.<br><br>Includes containers with up to the following Weapons Grade Plutonium (WG Pu) Equivalent value: 6 kilograms |
| B. Containerized Radioactive Waste | Plutonium, americium, or uranium contaminated waste | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC | SH, CC, CR, GN, RT | ADB | Considered in Safety Analysis as radioactive material source for facility fire, spill, puncture, container explosion, facility explosion, and criticality events.<br><br>Includes containers with up to the following Weapons Grade Plutonium (WG Pu) Equivalent values: 0.5 grams (LLW drum), 3 grams (LLW box), 200 grams (TRU drum), 320 grams (TRU box), 1,255 grams (POC), 320 grams (repackaging glovebox), 320 grams (contamination cell) |
| C. In Process Radioactive Waste, and/or Newly Generated Radioactive Waste | Plutonium, americium, or uranium contaminated waste | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box | CC, CR, GN, RT | ADB | Considered in Safety Analysis as radioactive material source for facility fire, spill, puncture, container explosion, and facility explosion. |



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## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **4. RADIOACTIVE MATERIALS:** (continued) | | | | | |
| D. Contamination Outside Filtered Enclosures/ Areas | *e.g.*, Limited radioactive material on drums, building structure, and filters | Not applicable | SH CC, CR, GN, RT, RA | <u>HAZARD CONTROL</u><br>• No container opening<br><u>IW PROTECTION</u><br>• Confinements<br>• Dosimetry, respiratory protection, contamination protection clothing<br>• Maintenance work evaluation, area surveys, radiation work permits, work control, postings, ALARA, training | **Standard Industrial Hazard**<br>Levels of contamination have been negligible on drums, building structure, and removed HEPA filters (filters treated as LLW);<br>No risk posed to the CW or the public from contamination.<br>Credited SMPs: PROC; RAD; TRAIN; TS&M; WMEP; and WORK |
| **5. THERMAL ENERGY:** | | | | | |
| A. Heated Water | Water at <201°F | Insulated steel piping | SH, RA | <u>HAZARD CONTROL</u><br>• Current configuration control<br><u>IW PROTECTION</u><br>• Piping, insulation<br>• Non-absorbent thermal protection clothing<br>• System inspection/monitoring, maintenance work evaluation, work control, labeling, training | **Standard Industrial Hazard**<br>No potential for initiation of fires;<br>No risk posed to the CW or the public, IW risk only.<br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; TS&M; and WORK |
| B. Flammable Gases | *e.g.*, Propane and acetylene gas used for some maintenance activities (propane storage tanks above and near facility), Natural gas used for facility heating boilers | Limited capacity gas cylinders; Large capacity steel tanks, Steel piping | SH, GN, RT, RA | ADB | Considered in Safety Analysis as material fire, facility fire, and facility explosion initiators/precursors. |

## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **5. THERMAL ENERGY: (continued)** | | | | | |
| C. Hot Work (not involving flammable gases) | *e.g.*, Welding, grinding, cutting | Standard welding equipment, standard power tool | GN, RA | ADB | Considered in Safety Analysis as material fire, facility fire, and facility explosion initiators/precursors. |
| D. Pyrophoric Materials | Uranium or plutonium metal parts and uranium fines | Approved DOT Type B shipping containers and a 10-gal drum | SH, CC, GN, RT | ADB | Considered in Safety Analysis as a material fire initiator/precursor. |
| E. Electric Power System | *e.g.*, Wiring, switchgear, motors | Not applicable | SH, CC, CR, GN, RT, RA | ADB | Considered in Safety Analysis as material fire, facility fire, and facility explosion initiators/precursors. |
| F. Electric Heaters | Moderate size room heaters | Not applicable | RA | <u>HAZARD CONTROL</u><br>• System maintenance<br>• Current configuration control<br>• Combustible control<br><br><u>IW PROTECTION</u><br>• Elevation, heater enclosures<br>• Thermal protection & insulated clothing<br>• System inspection/monitoring, maintenance work evaluation, work control, postings, training, lockout/tagout | **Standard Industrial Hazard**<br>Due to heaters typically being located at ceiling heights they are not considered to be a significant fire initiator; electric power system fire initiators considered to bound heater risk;<br>No risk posed to the CW and the public beyond that posed by loss of power events.<br><br>Credited SMPs: ORG; CONFIG; FIRE; INS; PROC; TRAIN; TS&M; and WORK |
| G. Diesel Generator, Day Tank, Batteries | *e.g.*, A 256kW generator, diesel engine, 180-gallon diesel fuel oil day tank, starting batteries | Not applicable | RA | <u>HAZARD CONTROL</u><br>• System maintenance<br>• Current configuration control<br>• Combustible control<br><br><u>IW PROTECTION</u><br>• Separate & locked facility<br>• Thermal protection & insulated clothing<br>• System inspection/monitoring, maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>No radioactive material releases associated with waste management facility fires;<br>No risk posed to the CW and the public beyond that posed by loss of power events, IW risk only.<br><br>Credited SMPs: ORG; CONFIG; FIRE; INS; PROC; TRAIN; TS&M; WMEP; and WORK. |



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## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **5. THERMAL ENERGY:** (continued) | | | | | |
| H. Transport Vehicles | *e.g.*, Standard diesel-fueled trucks and cargo trailers | Not applicable | SH | See Site SAR (Ref. 2) | Considered in Site SAR Safety Analysis (Ref. 2) as a facility fire initiator/precursor. Not addressed in NSTR-006-99. |
| **6. PRESSURE SOURCES:** | | | | | |
| A. Compressed Air, Compressors | Compressors up to 130 psi,<br>Air systems up to 90 psi normal operating pressure | Piping and compressors | CR,<br>RT,<br>RA | <u>HAZARD CONTROL</u><br>• Current configuration control<br><br><u>IW PROTECTION</u><br>• Piping, components, relief valves<br>• Eye shields<br>• System inspection/monitoring, maintenance work evaluation, work control, labeling, training, lockout/tagout | **Standard Industrial Hazard**<br>No radioactive material release associated with air system failures due to relatively low system pressures, radioactive material container strength, and radioactive material proximity;<br>No risk posed to the CW and the public, IW risk only.<br><br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; TS&M; WMEP; and WORK. |
| B. Hydraulic Equipment | *e.g.*, Drum crusher, drum lifting device, waste box tipper, construction equipment | Not applicable | SH,<br>CR,<br>GN,<br>RT | <u>HAZARD CONTROL</u><br>• LLW restriction<br>• Current configuration control<br><br><u>IW PROTECTION</u><br>• Components<br>• Eye shields<br>• Component inspection, maintenance work evaluation, work control, training | **Standard Industrial Hazard**<br>Levels of contamination have been negligible on drums to be crushed but output treated as LLW;<br>No risk posed to the CW or the public from contamination.<br><br>Credited SMPs: CONFIG; INS; PROC; TRAIN; TS&M; WMEP; and WORK. |
| C. Compressed Gas Cylinders | Various | Standard compressed gas bottles | SH,<br>RT,<br>RA | ADB | Considered in Safety analysis as a puncture initiator/precursor. |
| D. Water Lines | Up to 80 psi normal operating pressure | Steel piping | RA | <u>HAZARD CONTROL</u><br>• Current configuration control<br><br><u>IW PROTECTION</u><br>• Piping, relief valves<br>• System inspection/monitoring, maintenance work evaluation, work control, labeling, training | **Standard Industrial Hazard**<br>No potential for radioactive material release due to relatively low pressures;<br>No risk posed to the CW or the public, IW risk only.<br><br>Credited SMPs: CONFIG; INS; PROC; TRAIN; TS&M; and WORK. |

**Table 5-4 Waste Management Facilities Hazard Description Summary**

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **7. KINETIC ENERGY:** | | | | | |
| A. Vehicles, Material Handling Equipment | Electric forklifts, diesel forklifts used outside, hand controlled lifts | Not applicable | SH, CC, CR, GN, RT, RA | ADB | Considered in Safety Analysis as material fire, spill, and puncture initiators/precursors. |
| B. Rotating Machinery & Tools | *e.g.*, Fans, pumps, compressors, rotating cutting tools, bag cut spinners, drum crusher | Not applicable | GN, RT, RA | <u>HAZARD CONTROL</u><br>• Current configuration control<br><u>IW PROTECTION</u><br>• Component enclosures, speed governors<br>• Eye shields, non-loose clothing<br>• System inspection/monitoring, tool inspections, postings, lockout/tagout, maintenance work evaluation, training work control | **Standard Industrial Hazard**<br>Rotating machinery is not located near any significant quantities of radioactive material and poses no risk to the CW and the public; Tools may be used near radioactive materials but insufficient energy to cause container damage and poses no risk to the CW and the public.<br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; TS&M; WMEP; WORK |
| C. Suspended Loads/Material | *e.g.*, Overhead cranes and hoists, hoisting and rigging equipment and accessories (slings, lifting devices, shackles, eyebolts, turnbuckles, etc.) | Varies | SH, RT, RA | ADB | Considered in the Safety Analysis as material spill initiator/precursor. |
| **8. POTENTIAL ENERGY:** | | | | | |
| A. Raised or Suspended Loads/Material | *e.g.*, Forklifts, drum lifters, overhead cranes and hoists, hoisting and rigging equipment and accessories (slings, lifting devices, shackles, eyebolts, turnbuckles, etc.) | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC | SH, RT, RA | ADB | Considered in the Safety Analysis as material spill initiator/precursor. |



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**Table 5-4** Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **8. POTENTIAL ENERGY:** (continued) | | | | | |
| B. Stacked Waste Containers | Waste drums up to four high and waste boxes up to two high | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC | SH | ADB | Considered in the Safety Analysis as material spill initiator/precursor. |
| **9. TOXIC, HAZARDOUS, OR NOXIOUS CHEMICALS:** | | | | | |
| A. General Industrial Chemicals; Bulk or Process Chemicals below Thresholds of Concern (*i.e.*, TPQs listed in 40 CFR 355 or TQs listed in 40 CFR 68 and 29 CFR 1910.119) | *e.g.*, Laboratory chemicals, paints, developer fluid, sealers, maintenance supplies, air conditioner refrigerant | Standard containers: drums, vials, bottles, bags, cans, *etc.* | SH, CC, GN, RT, RA | HAZARD CONTROL<br>• Chemical package<br>• Quantity control<br>• Current configuration control<br><br>IW PROTECTION<br>• Protective clothing, eyewash & safety showers, respirators<br>• Chemical inventory, area restrictions, area surveys, maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>Chemical inventories are below evaluation thresholds and pose no risk to the CW and the public, IW risk only.<br><br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; TS&M; WMEP; and WORK. |
| B. Bulk, Process, or Waste Chemicals Potentially Exceeding Thresholds of Concern (*i.e.*, TPQs listed in 40 CFR 355, or TQs listed in 40 CFR 68 and 29 CFR 1910.119) | *e.g.*, Cupric Chloride, Dihydrate exceeding RQ threshold of 10 pounds | Standard chemical container | SH, CC, GN, RT, RA | Considered in individual facility –specific AB documents on a case-by-case basis due to the potential variability amongst waste management facilities. | Considered in individual facility –specific AB documents on a case-by-case basis due to the potential variability amongst waste management facilities. Generally, if a chemical exceeds the 40 CFR 302 RQ but is below a defined TQ or TPQ or doesn't have a defined TQ or TPQ, it is a **Standard Industrial Hazard** (See Hazard/Energy Source 9A above). |

**Table 5-4** Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **9. TOXIC, HAZARDOUS, OR NOXIOUS CHEMICALS:** (continued) | | | | | |
| C. RCRA Hazardous Waste | Hazardous chemical contaminated waste | Approved on-site shipping containers;<br>55-gal drum, SWB, metal waste box | SH, CC, GN, RT | <u>HAZARD CONTROL</u><br>• Current configuration control, waste containers/packaging, RCRA permit control requirements<br><u>IW PROTECTION</u><br>• Work control, postings, training | **Standard Industrial Hazard**<br>Chemical control and the RCRA waste management program are relied upon to mitigate the consequences to the IW of the hazard;<br>No risk posed to the CW and the public;<br>RCRA wastes exceeding thresholds of concern are addressed in Hazard/Energy Source 9B.<br>Credited SMPs: ORG; INS; PROC; TRAIN; WMEP; and WORK. |
| D. Beryllium | *e.g.*, Parts; Beryllium contaminated waste | Approved on-site shipping containers;<br>55-gal drum, SWB, metal waste box | SH, CC, GN, RT | <u>HAZARD CONTROL</u><br>• Current material form control<br><u>IW PROTECTION</u><br>• Protective clothing<br>• Area restrictions, area surveys, maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>Beryllium located in identified waste containers;<br>No risk posed to the IW, the CW, and the public due to form of material.<br>Credited SMPs: INS, PROC; TRAIN, WMEP; and WORK |
| E. Asbestos | *e.g.*, Ceiling tiles, floor tiles, walls, piping insulation; waste containers | Not applicable; approved on-site shipping containers;<br>55-gal drum, SWB, metal waste box | SH, CC, GN, RT, RA | <u>HAZARD CONTROL</u><br>• Current configuration control, waste containers<br><u>IW PROTECTION</u><br>• Protective clothing, respirators<br>• Area restrictions, area surveys, maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>Asbestos abatement is relied upon to mitigate the consequences to the IW of the hazard;<br>No risk posed to the CW and the public.<br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; TS&M; WMEP; and WORK. |
| F. Polychlorinated Biphenyls (PCBs) | *e.g.*, Transformer fluids; lighting ballasts | Transformer and lighting ballasts | SH, CC, GN, RT, RA | <u>HAZARD CONTROL</u><br>• Current configuration control, waste containers<br><u>IW PROTECTION</u><br>• Protective clothing<br>• Maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>Chemical control and TSCA waste management programs are relied upon to mitigate the consequences to the IW of the hazard;<br>No risk posed to the CW and the public.<br>Credited SMPs: CONFIG; INS; PROC; TRAIN; TS&M; WMEP and WORK. |



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## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **9. TOXIC, HAZARDOUS, OR NOXIOUS CHEMICALS:** (continued) | | | | | |
| G. Lead | *e.g.*, Batteries; paints, sealant | Not applicable | SH CC, GN, RT, RA | HAZARD CONTROL<br>• Current configuration control, waste containers<br>IW PROTECTION<br>• Protective clothing<br>• Area restrictions, area surveys, maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>Chemical control and RCRA waste management programs are relied upon to mitigate the consequences to the IW of the hazard;<br>No risk posed to the CW and the public.<br><br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; TS&M; WMEP and WORK. |
| H. Batteries | *e.g.*, Lead acid batteries for diesel support; nickel-cadmium batteries for tenant activities; standard emergency lighting and panel batteries | Not applicable | SH CC, GN, RT, RA | HAZARD CONTROL<br>• Component package<br>IW PROTECTION<br>• Protective clothing, eyewash & safety showers<br>• Component inspections, work control, training | **Standard Industrial Hazard**<br>Waste management programs are relied upon to mitigate the consequences to the IW of the hazard;<br>No risk posed to the CW and the public.<br><br>Credited SMPs: INS; PROC; TRAIN; WMEP; and WORK. |
| I. Diesel Fuel (Gasoline) | *e.g.*, Day tanks, above-ground, tanks; gasoline fuel tank for drum crusher motor | Tanks | RT, RA | HAZARD CONTROL<br>• Approved storage tanks<br>IW PROTECTION<br>• Postings, work control, training | **Standard Industrial Hazard**<br>Health and safety programs are relied upon to mitigate the consequences to the IW of the hazard;<br>Fire safety programs are relied upon to control the fire hazard (see THERMAL ENERGY and OTHER HAZARDS);<br>No risk posed to the CW and the public.<br><br>Credited SMPs: INS; PROC; TRAIN; and WORK. |
| **10. INADEQUATE VENTILATION:** | | | | | |
| A. Unventilated Areas | Following loss of ventilation, tunnels and basements <u>may</u> become confined spaces | Not applicable | SH, GN, RA | HAZARD CONTROL<br>• Area surveys/monitoring<br>• Current configuration control<br>IW PROTECTION<br>• Controlled access, locked doors<br>• Breathing air<br>• Area restrictions, area surveys, work control, postings, training | **Standard Industrial Hazard**<br>Health and safety programs are relied upon to mitigate the consequences to the IW of the hazard;<br>No risk posed to the CW and the public.<br><br>Credited SMPs: ORG; CONFIG; INS; PROC; TRAIN; WMEP; and WORK. |

## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **11. MATERIAL HANDLING:** | | | | | |
| A. Handling, Transfer, and Shipment of Waste Containers | Removing/loading waste containers from/on transport vehicles; moving waste containers between dock and storage location; moving waste containers within facility for inspections, during waste assay, due to waste generation, or removal of specific containers | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC, approved DOT Type B shipping containers | SH, CC, CR, RT, GN | ADB | Considered in Safety Analysis as material fire, spill, and puncture initiators/precursors.<br><br>See Hazard/Energy Source 7A, *Vehicles, Material Handling*; Hazard/Energy Source 7C, *Suspended Loads/Materials;* and Hazard/Energy Source 8A, *Raised or Suspended Loads/Material.* |
| **12. UNKNOWN OR UNMARKED MATERIALS:** | | | | | |
| A. Waste to be Repackaged | Unknown materials may be the reason for repackaging the waste | Poly liner inside rigid liner inside drum | GN, RT | ADB | Considered in Safety Analysis as spill and fire initiators/precursors. See Hazard/Energy Source 13B, *Incompatible Chemicals.* |
| **13. OTHER HAZARDS:** | | | | | |
| A. Flammable Gas Generation in Metal Waste Containers | Sealed containers with radioactive & other materials capable of generating flammable gas | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC | SH, CC, CR, RT | ADB | Considered in Safety Analysis as a container explosion initiator/precursor. |



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## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **13. OTHER HAZARDS:** (continued) | | | | | |
| B. Incompatible Chemicals | Incompatible (reactive) chemicals may be packaged together in a waste container | Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC; repackaging glovebox | SH, CC, CR, GN, RT | ADB | Considered in Safety Analysis as fire, spill, and explosion initiators/precursors. |
| C. Battery Charging Stations | Battery chargers for forklift batteries | Not applicable | SH CC, CR GN, RT, RA | HAZARD CONTROL<br>• Current configuration control<br>• Combustible control<br>IW PROTECTION<br>• Component enclosure<br>• Protective clothing, eye shields<br>• Component inspections, work control, postings, training, lockout/tagout | **Standard Industrial Hazard**<br>Charging stations typically located in an area without radioactive material storage or separated from waste containers;<br>Explosions or fires from chargers or batteries is isolated from waste containers by interior walls and/or separation;<br>No risk posed to the CW or the public.<br>Credited SMPs: CONFIG; FIRE; INS; PROC; TRAIN; WMEP; and WORK. |
| D. Structure Degradation and Leakage | Cracks in tunnel wall with ground water in-leakage and potential structural degradation | Not applicable | SH | ADB | Considered in Safety Analysis as material fire, spill, and puncture initiators/precursors. |
| E. Diesel Fuel (Gasoline) Storage Tank Combustibles | *e.g.*, Day tanks, above-ground, tanks; gasoline fuel tank associated with drum crusher motor | Tanks | RT, RA | HAZARD CONTROL<br>• System maintenance<br>• Current configuration control<br>• Hot work control<br>IW PROTECTION<br>• Separate facility, locked facility<br>• System inspection/monitoring, maintenance work evaluation, work control, postings, training | **Standard Industrial Hazard**<br>Diesel fuel is located in areas without radioactive material storage;<br>Fires from diesel fuel are isolated from waste containers by exterior walls;<br>No risk posed to the CW or the public.<br>Credited SMPs: ORG; CONFIG; FIRE; INS; PROC; TRAIN; TS&M; WMEP; and WORK. |
| F. Floor Loading | Stacked waste storage areas over basement open areas | Not applicable | SH | ADB | Considered in Safety Analysis as material fire, spill, and puncture initiators/precursors. |



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## Table 5-4 Waste Management Facilities Hazard Description Summary

| Hazard / Energy Source | Form / Description | Packaging | Interact Activities | Credited Protective Features | Remarks |
|---|---|---|---|---|---|
| **13. OTHER HAZARDS:** (continued) | | | | | |
| G. Combustibles | *e.g.,* Wooden pallets, plywood sheets, office area combustibles, miscellaneous flammable chemicals | Flammable chemicals in flammable liquid storage cabinets, not applicable for other combustibles | SH, RA | ADB | Combustibles or various types may exist at times within the waste storage facility;<br><br>Considered in Safety Analysis as a facility fire initiator/precursor and propagator. |
| H. Natural Phenomena or External Event | *e.g.,* Seismic events, high winds, tornadoes, heavy rain, heavy snow, flooding, freezing, lightning, aircraft crash, range fires | Approved DOT Type B shipping containers, Approved on-site shipping containers; 55-gal drum, SWB, metal waste box, POC | SH, CC, CR, GN, RT | ADB | Considered in Safety Analysis as material fire, spill, puncture, and facility fire/explosion initiators/precursors.<br><br>(seismic events, high winds, tornadoes, and heavy snow can potentially impact natural gas lines/boilers leading to explosion). |

## 5.1 HIGH VOLTAGE (HAZARD/ENERGY SOURCE 1)

13.8kV Transformers (Sub-hazard 1A)

Numerous 13.8 kV to 480 V transformers (typical size) are located throughout the site to support waste management facility activities. The transformers present a significant electrical hazard that potentially can initiate fires and electrocute personnel. The transformer areas are generally cleared but grasses (*i.e.*, potential for external event range fire) are located near some of the transformer enclosures. No radioactive materials are located close enough to the transformers to be impacted by transformer-related hazards and, therefore, the hazard associated with the transformers is considered a Standard Industrial Hazard and will not be further evaluated. However, low voltage electric power systems are located in areas containing radioactive material and are potential fire initiators (see Section 5.4).

Protective features credited in the determination that electric transformers are a Standard Industrial Hazard are:

- Separation from hazardous materials [CONFIG]
- Combustible control - separation from combustibles [FIRE]
- Physical barriers – fenced areas, insulated enclosures [INS]
- Administrative – lockout/tagout, postings, training, work control [INS, PROC, TRAIN, WORK]

## 5.2 DIRECT RADIATION SOURCES (HAZARD/ENERGY SOURCE 3)

Sealed Sources (Sub-hazard 3A)

Sealed sources are radioactive material sources that may be stored within source lockers and vaults in waste management facilities. Sealed sources are typically used to calibrate equipment and devices in waste management facilities in support of CR activities. The sources present a radiation hazard that potentially can yield significant personnel radiation exposures. The sources, in most cases, contain relatively small amounts of radioactive material. The sources are considered a Standard Industrial Hazard due to the rigor associated with source packaging. These hazards will not be further evaluated.

Protective features credited in the determination that sealed sources are a Standard Industrial Hazard are:

- Containment - source packaging [INS]
- Physical barriers – source packaging, shielding [INS, RAD]
- Protective equipment – dosimetry, leaded clothing [RAD]
- Administrative – source inspection, postings, source package quality, ALARA, source use evaluation, source control training, work control, [ORG, INS, PROC, QA, RAD, TRAIN, TS&M, WORK]



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Radiation Generating Equipment (Sub-hazard 3B)

Radiation generating equipment (Sub-hazard 3B) is typically located in waste management facilities in which non-destructive testing (NDT) of waste is performed as part of CR activities. Radiation generating equipment presents an ionizing radiation hazard that potentially can yield significant personnel radiation exposures. Due to the distance separating the radiation generating equipment from the CW and the public, radiation generated by the device poses no risk to either receptor. For this reason, radiation generating equipment is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that radiation generating equipment is a Standard Industrial Hazard are:

- Current configuration control [CONFIG]
- Physical barriers – device shielding [INS, RAD]
- Protective equipment - dosimetry [RAD]
- Administrative – device inspection, device control, postings, work control, training [ORG, INS, PROC, RAD, WORK, TRAIN]

Radiation from Stored/Staged Waste Containers (Sub-hazard 3C)

The storage and staging of radioactive materials in waste management facilities presents a direct radiation hazard that can potentially affect the IW and CW radiation exposures. Due to the separation of radioactive materials for the CW and the public and stringent compliance with ALARA principles, the radiation from stored/staged waste containers hazard is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that radiation from stored/staged waste containers is a Standard Industrial Hazard are:

- Current configuration control – waste containers, separation [CONFIG]
- Physical barriers –shielding [INS, RAD]
- Protective equipment – protective clothing and equipment, dosimetry [INS, RAD]
- Administrative – maintenance work evaluation, area surveys, radiation work permits, postings, ALARA, work control, training [ORG, INS, PROC, RAD, WORK, TRAIN]

## 5.3 RADIOACTIVE MATERIALS (HAZARD/ENERGY SOURCE 4)

Category I and II SNM (Sub-hazard 4A)

Part of the waste management mission is to receive, stage, and then transfer on-site or ship off-site DOT approved, Type B shipping containers containing Category I and II quantities of plutonium, uranium, and/or americium metals and/or oxides. Currently, this activity is only performed at the Building 991 Complex. The radioactive materials present a significant radiological hazard that potentially can yield IW, CW, and public radiation exposures. Release



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mechanisms for the material include: (1) exposure of pyrophoric material to atmosphere with subsequent fires; (2) material involvement in non-pyrophoric, facility fires; (3) material involvement in container spill events, (4) material involvement in container puncture events, (5) material involvement in facility explosion events, and (6) criticality events. Many of these release mechanisms are expected to be precluded due to the rigor of the Type B shipping container. The Type B shipping containers containing Category I or II SNM are not opened. Exposure of pyrophoric material to the atmosphere is also expected to be precluded since the receipt of SNM will comply with the requirements specified in 1-W89-HSP-31.11 (Ref. 19), on-site transportation procedures, and Department of Transportation (DOT) procedures which limit the amount of known pyrophoric material. The quantity of WG Pu or uranium in the Type B shipping container varies for each container. Category I SNM requires two or more kilograms of plutonium metal or six or more kilograms of plutonium oxide. The Category I and II SNM hazard is further evaluated and the protective features are identified in later sections of this report.

Containerized Radioactive Waste (Sub-hazard 4B)

Part of the waste management mission is to receive, store, and then transfer on-site transportation approved shipping containers containing plutonium, uranium, and/or americium contaminated wastes. The radioactive materials present a significant radiological hazard that potentially can yield IW, CW, and public radiation exposures. Release mechanisms for the material include: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires; (2) material involvement in non-pyrophoric, facility fires; (3) material involvement in container spill events, (4) material involvement in container puncture events, (5) hydrogen generation in containers with subsequent container explosion events, (6) material involvement in facility explosions, and (7) criticality events. Contaminated waste material shipping containers are not opened unless they are located within a HEPA-filtered enclosure/area. The quantity of WG Pu or uranium in the waste shipping container varies for each container type. The maximum fissile material loading (in terms of WG Pu equivalent dose impact) for each analyzed container is shown in Table 5-5 and is based on: (1) upper-bound quantities for containers within the defined waste category, in the case of LLW containers; (2) container, glovebox, or fissionable material limits imposed by Criticality Safety in the case of TRU waste containers other than POCs; and (3) container fissionable material limits imposed by Criticality Safety in combination with a maximum planned americium loading, in the case of POCs. Table 5-5 is presented to support development of accident scenarios (to determine the effective MAR) and should not be interpreted as Nuclear Material Safety Limits (NMSLs) for the Site.

Conservative assumptions dealing with damage ratios, inventories, and container contents that go into the MAR estimate for accident scenarios are expected to cover several variations of drum totals and stacking arrangements. The waste container hazard is further evaluated and the protective features are identified in later sections of this report.

The chemical and physical forms of the containerized wastes vary, but are categorized by the Item Description Code (IDC) or Waste Form Code (WFC) assigned to them. The wastes are contaminated primarily with WG Pu. Uranium contaminated wastes may be found at the Site but are not explicitly evaluated; WG Pu postulated release evaluations are used to bound similar scenario releases involving uranium due to the significantly higher DCF associated with plutonium versus uranium. Some of the wastes may be contaminated with higher concentrations of americium than normally found in WG Pu from the decay of $^{241}Pu$ to $^{241}Am$. This Safety Analysis will address the issue of americium in waste containers and will identify appropriate controls associated with the material.

**Table 5-5** Analyzed Waste Container Material Loading

| Container Type | Waste Type | Analyzed WG Pu Equivalent Limits |
|---|---|---|
| 55-gallon waste drum | LLW | 0.5 grams |
| 55-gallon waste drum | TRU waste | 200 grams |
| POC | TRU waste | 1,255 grams |
| wooden box | LLW | 3 grams |
| TRUPACT II SWB | TRU waste | 320 grams |
| metal waste box | LLW & TRU waste | 3 grams (LLW) and 320 grams (TRU) |

<u>In Process Radioactive Waste, Newly Generated Radioactive Waste (Sub-hazard 4C)</u>

It is assumed that waste management facilities handle radioactive material containers of various types on a regular basis. No identified contamination of any significance is present in the facilities outside HEPA-filtered enclosures/areas. However, repackaging activities increase the likelihood of contamination events within HEPA-filtered enclosures/areas. The radioactive materials present a radiological hazard that potentially can yield IW, CW, and public radiation exposures. Release mechanisms for the materials include: (1) contaminated materials involved in fire events, (2) contaminated materials involvement in spill events, (3) contaminated materials involved in puncture events, and (4) hydrogen generation in containers with subsequent container explosion events. The in-process radioactive waste and newly generated radioactive waste hazard is further evaluated and the protective features are identified in later sections of this report.

<u>Contamination Outside Filtered Enclosures/Areas (Sub-hazard 4D)</u>

Waste management facilities handle radioactive material containers of various types on a regular basis. No identified contamination of any significance is present in the facilities outside HEPA-filtered enclosures/areas. No waste containers and Type B shipping containers are to be opened in a waste management facility unless they are located within a HEPA-filtered enclosure/area. Therefore, the generation of any new contamination is limited to accidental spills outside of a HEPA-filtered enclosure/area. The limited radioactive contamination potential outside of containers or HEPA-filtered enclosures/areas presents possible personnel radiation exposures. HEPA filters in plenums and drums processed through the drum crushing activity are treated as LLW and have the potential to contain small amounts of contamination. Based on the experience from past operation of waste management facilities and the requirements for opening containers in a waste management facility, contamination outside of waste containers or outside HEPA-filtered enclosures/areas is considered a Standard Industrial Hazard with no risk posed to the CW or the public and will not be further evaluated.

Protective features credited in the determination that radioactivecontamination is a Standard Industrial Hazard are:

- Containment of contamination – no container opening outside of HEPA-filtered enclosures/areas [WMEP]
- Physical barriers – confinements [RAD]
- Protective equipment – dosimetry, respiratory protection, contamination protection clothing [RAD]
- Administrative - maintenance work evaluation, area surveys, radiation work permits, postings, ALARA, training, no container opening outside of HEPA-filtered enclosure/area, work control [PROC, RAD, TRAIN, TS&M, WMEP, WORK]

## 5.4 THERMAL ENERGY (HAZARD/ENERGY SOURCE 5)

Heated Water (Sub-hazard 5A)

Heated water is used for heating various waste management facilities (including associated support buildings). Heated water lines present a thermal hazard that can potentially burn facility personnel but is not a potential fire initiator since the temperature of the water is less than 201°F. No radioactive materials are located close enough to heated water lines to be impacted by thermal hazards associated with hot water and, therefore, the thermal hazard associated with heated water is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that heated water is a Standard Industrial Hazard are:

- Current configuration control – limitation on temperature, separation from hazardous materials [CONFIG]
- Physical barriers – piping, insulation [INS]
- Protective equipment – non-absorbent thermal protection clothing [INS]
- Administrative – system inspection/monitoring, maintenance work evaluation, labeling, training [ORG, INS, PROC, TRAIN, TS&M, WORK]

Flammable Gases (Sub-hazard 5B)

Natural Gas - natural gas boilers are used to heat water for portions of some waste management facility heating systems. The natural gas lines to the boilers are typically above ground making them susceptible to physical damage. Failure of the boilers or natural gas lines could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to a natural gas explosion in proximity to containers; (2) facility fires involving natural gas; and (3) facility explosions involving natural gas.

Propane, Acetylene - as part of waste management facility operations, flammable gas torches may be used for pipe brazing or other tasks. A small, hand-held torch is the expected flammable gas component. Torch use is not expected to be a frequent activity, but some use is



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expected. Locations for use are not defined but may include waste storage areas. Flammable gases associated with the torch could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to a propane explosion in proximity to containers; (2) facility fires involving direct container exposure to torch flame; and (3) facility explosions involving flammable gases. In addition, propane storage tanks are located near several waste management facilities (*e.g.*, on elevated terrain west of the Building 991 Complex and east of Building 906) and may pose a hazard to these facilities if breached.

The flammable gas hazard is further evaluated and protective features are identified in later sections of this report.

Hot Work (not involving flammable gases) (Sub-hazard 5C)

In addition to Sub-hazard 5B, other activities could be performed in waste management facilities that generate heat or sparks that could become fire initiators (*e.g.*, welding, grinding). Hot work is not expected to be a frequent activity, but some hot work is expected. Locations for use are not defined but may include waste storage areas. Hot work could result in: (1) ignition of combustible materials (Sub-hazards 5B and 13G) resulting in a fire that impacts nearby containers or enclosures; and (2) facility fires involving direct exposure of hot work to containers or enclosures.

The hot work hazard is further evaluated and protective features are identified in later sections of this report.

Pyrophoric Materials (Sub-hazard 5D)

Part of the waste management mission, specifically the Building 991 Complex, is to receive, stage, and then ship DOT approved, Type B shipping containers containing Category I and II quantities of plutonium or uranium metal. Uranium metal fines may also be stored in waste management facilities (typically stored in 10-gallon drums). The radioactive metals and fines are potentially pyrophoric and may spontaneously ignite when exposed to atmosphere. The pyrophoric materials present a significant radiological hazard that potentially can yield IW, CW, and public radiation exposures following the ignition and burning of the radioactive material as covered by material fires in this Safety Analysis. Type B shipping containers (for Category I and II quantities of plutonium or uranium metal) and waste drums (for uranium fines) provide protection against the exposure of the pyrophoric material to air. The Type B shipping containers and the waste containers are not opened in the waste management facilities unless in an inert atmosphere. The pyrophoric radioactive material hazard is further evaluated and the protective features are identified in later sections of this report.

Electric Power System (Sub-hazard 5E)

Electric power wiring and electrical components exist throughout waste management facilities. Failure of the electric power system by shorts or loss of insulation could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to ignition of an explosion in proximity to containers; (2) ignition of facility fires involving combustibles; and



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(3) ignition of facility explosions involving flammable gases. The electric power system hazard is further evaluated and the protective features are identified in later sections of this report.

Electric Heaters (Sub-hazard 5F)

Some portions of the waste management facilities do not have heating support from the heated water system and alternative means for conditioning the air in the locations are required. Electric heaters are utilized to maintain proper temperatures in these areas. The electric heaters present thermal and electrical hazards that can potentially result in the initiation of a fire, burn personnel, and electrocute personnel. The electric heaters are typically ceiling-mounted reducing the associated thermal and fire initiation hazards including the effects on waste containers potentially stored in the same room as the electric heater(s). General fire initiation frequencies corresponding to electric power system failures and personnel errors are used in this Safety Analysis and bound any fire initiation frequency contribution related to the elevated heaters and stored waste containers. Therefore, the thermal, fire initiation, and electrocution hazard associated with the electric heaters is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that hazards associated with electric heaters are Standard Industrial Hazards are:

- System maintenance [TS&M]
- Current configuration control - separation from hazardous materials and combustibles [CONFIG, FIRE, WMEP]
- Physical barriers – elevation, heater enclosures [INS]
- Protective equipment – thermal protection clothing, insulated clothing [INS]
- Administrative – system inspection/monitoring, maintenance work evaluation, work control, postings, training [ORG, FIRE, INS, PROC, TRAIN, TS&M, WORK]

Diesel Generator, Day Tank, Batteries (Sub-hazard 5G)

Some waste management facilities may be supported by a backup power diesel generator and associated auxiliary equipment. A typical configuration includes a diesel generator, a day tank containing up to 180 gallons of diesel fuel, and starting batteries. This combined set of equipment presents thermal and electrical hazards that can potentially result in the initiation of a fire, burn personnel, and electrocute personnel. No radioactive materials are located in or near diesel generators. Fires initiated by diesel generators and auxiliary equipment could impact electric power supply to the supported facility, but the frequency associated with the loss of electric power is dominated by other electrical system failure modes. Therefore, the thermal, fire initiation, and electrocution hazard associated with diesel generators and auxiliary equipment is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that diesel generators, day tanks, and batteries are Standard Industrial Hazards are:

- Maintenance of system barriers [TS&M]



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- Current configuration control - separation from hazardous materials and combustibles [CONFIG, FIRE, WMEP]
- Physical barriers – separate facility, locked facility [ORG, CONFIG]
- Protective equipment – thermal protection clothing, insulated clothing [INS]
- Administrative – system inspection/monitoring, maintenance work evaluation, work control, postings, training [ORG, FIRE, INS, PROC, TRAIN, TS&M, WORK]

Transport Vehicles (Sub-hazard 5H)

Part of the waste management mission is to receive and ship off-site DOT approved, Type B shipping containers containing Category I and II quantities of plutonium, uranium, and/or americium metals and/or oxides and on-site transfer of approved containers containing plutonium, uranium, and/or americium contaminated wastes. Also, various non-radioactive material deliveries and shipments will occur as part of normal operations and tenant activities. The use of transportation vehicles during the conduct of these receipt and transfer/shipment activities presents a potential flammable material hazard from the diesel or gasoline fuels in the vehicles and an ignition source from the hot surfaces of the vehicles that can lead to facility fires. In conjunction with the radioactive material receipt and transfer/shipment, radioactive material containers are located on or in proximity to the transport vehicles. Transport vehicle hazards and potential accident scenarios are further evaluated in the Site SAR (Ref. 2) and are not evaluated in this NSTR.

## 5.5 PRESSURE SOURCES (HAZARD/ENERGY SOURCE 6)

Compressed Air, Compressors (Sub-hazard 6A)

Various waste management facility equipment (*e.g.*, crate counter air table, RTR units) is supported by air compressors and corresponding pressurized air tanks and piping. Shutoff air pressure for the air compressors is typically between 80 and 90 pounds per square inch. This combined set of equipment presents pressure hazards that can potentially result in the generation of missiles (*i.e.*, pieces of equipment traveling at high velocity due to air system rupture) and personnel injury. Pressurized piping could be located throughout a facility, including through waste storage areas; however, the compressors and the air tank are not located in close proximity to stored waste containers. Due to the relatively low pressures associated with air compressor systems and auxiliary equipment, the pressure hazard is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that compressed air systems and compressors are Standard Industrial Hazards are:

- Current configuration control - limitation on pressure, separation from hazardous materials [CONFIG, WMEP]
- Physical barriers – piping, components, relief valves [INS]
- Protective equipment – eye shields [INS]



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- Administrative – system inspection/monitoring, maintenance work evaluation, work control, labeling, training, lockout/tagout [ORG, INS, PROC, TRAIN, TS&M, WORK]

Hydraulic Equipment (Sub-hazard 6B)

Hydraulically operated equipment may be used to support waste management operations. Hydraulically operated equipment includes such items as a drum crusher, a drum lifter, forklifts, and various construction equipment. Some hydraulically operated equipment, for example forklifts, may interface with other hazards identified in Table 5-4 (see Sub-hazards 4B and 4C) and could become an accident initiator/precursor. Hydraulically operated equipment as an accident initiator/precursor to spills and punctures is considered in the evaluation of Sub-hazards 4B and 4C. Hydraulic fluid as an accident initiator/precursor to fires is considered in the evaluation of facility fire scenarios.

Drums treated using the drum crusher are classified as LLW but generally have negligible contamination. The relatively high pressures associated with the drum crusher and the low levels of contamination present a pressure hazard and a contamination hazard (see Sub-hazard 4D). The pressure hazards associated with the use of hydraulically operated equipment are considered Standard Industrial Hazards and will not be further evaluated.

Protective features credited in the determination that hydraulic equipment is a Standard Industrial Hazard are:

- Limitation on contamination – LLW restriction for drums processed by the drum crusher [WMEP]
- Current configuration control – separation from hazardous materials [CONFIG, WMEP]
- Physical barriers – equipment components [INS]
- Protective equipment – eye shields [INS]
- Administrative – component inspection, maintenance work evaluation, work control, training [INS, PROC, TRAIN, TS&M, WORK]

Compressed Gas Cylinders (Sub-hazard 6C)

Compressed gas cylinders may be brought into waste management facilities (flammable compressed gases are addressed as Sub-hazard 5B). Nitrogen and oxygen are the most likely types of gases that will be used, but use of other gases is possible. The compressed gas is not expected to be a frequent activity, but some use is expected. Locations for use are not defined but may include waste storage and handling areas. The compressed gases could result in punctures of containers or enclosures due to the energy released if a gas cylinder valve were accidentally sheared off. The compressed gas bottles hazard is further evaluated and the protective features are identified in later sections of this report.

Water Lines (Sub-hazard 6D)

Water is supplied for fire suppression systems in several waste management facilities. The water enters facilities covered by a suppression system from the Site supply system at a nominal pressure of 80 psi. The water is then distributed throughout the facility for fire suppression needs. Due to the relatively low pressures associated with fire suppression systems, the pressure hazard is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that fire water lines are a Standard Industrial Hazard are:

- Current configuration control – limitation on pressure [CONFIG]
- Physical barriers – piping
- Administrative – system inspection/monitoring, maintenance work evaluation, labeling, training [INS, PROC, TRAIN, TS&M, WORK]

## 5.6 KINETIC ENERGY (HAZARD/ENERGY SOURCE 7)

Vehicles, Material Handling Equipment (Sub-hazard 7A)

Part of the waste management mission is to receive and ship off-site DOT approved, Type B shipping containers containing Category I and II quantities of plutonium, uranium, and/or americium metals and/or oxides and to receive and transfer on-site approved shipping containers containing plutonium, uranium, and/or americium contaminated wastes. Also, various non-radioactive material receipts, transfers, and shipments will occur as part of normal operations and tenant activities. The use of material handling equipment or vehicles during the conduct of these receipt, transfer, and shipment activities presents a potential kinetic energy hazard from the movement and mass of the equipment. The equipment can impact staged Type B shipping containers, staged waste containers, or stored waste containers that could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to container breach; (2) spill of container contents following impact-induced events; and (3) spill of container contents following puncture of the container or enclosures. The vehicles, material handling equipment hazard is further evaluated and the protective features are identified in later sections of this report.

Rotating Machinery & Tools (Sub-hazard 7B)

Rotating machinery may be located in various areas of the waste management facilities. No significant quantities of radioactive material beyond contamination levels are located close enough to rotating machinery to be impacted by the kinetic energy hazards associated with the machinery. Some rotating tools (*e.g.*, drills, saws) may be used during the conduct of construction and maintenance tasks but contain insufficient energy to cause failure of radioactive material containers except by direct application of the tool to the container. This latter hazard is considered sabotage and is not addressed in this Safety Analysis. Therefore, the kinetic energy hazard associated with rotating machinery and tools is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that rotating machinery and tools are a Standard Industrial Hazard are:

- Current configuration control – separation from hazardous materials for fixed machines [CONFIG, WMEP]; maintenance work evaluation and work control for tools [TS&M, WORK]
- Physical barriers – component enclosures, speed governors [INS]
- Protective equipment – eye shields, non-loose clothing [INS]
- Administrative – system inspection/monitoring, tool inspections, postings, lockout/tagout, maintenance work evaluation, training, work control [ORG, INS, PROC, TRAIN, TS&M, WORK]

Suspended Loads/Material (Sub-hazard 7C)

Overhead lifting devices (*e.g.*, overhead bridge cranes, hoist) will be used in several waste management facilities to move heavy objects including waste containers. It is possible that a suspended load could be moved or jerked with enough energy to impact a nearby enclosure, such as a glovebox, or waste material container(s) resulting in breaching material confinement. Such failures could result in a spill and subsequent radiological and/or toxicological release. The suspended loads/materials hazard is further evaluated and the protective features are identified in later sections of this report.

## 5.7 POTENTIAL ENERGY (HAZARD/ENERGY SOURCE 8)

Raised or Suspended Loads/Material (Sub-hazard 8A)

Part of the waste management mission is to receive and ship off-site DOT approved, Type B shipping containers containing Category I and II quantities of plutonium, uranium, and/or americium metals and/or oxides and to receive, handle, and transfer on-site approved containers containing plutonium, uranium, and/or americium contaminated wastes. The use of forklifts and drum lifting devices during the conduct of these receipt, handle, transfer, and shipment activities presents a potential energy hazard (*i.e.*, potential for dropping of containers) from the raising of the loads. Type B shipping container loads on forklifts are generally not required to be raised to any height above that necessary to clear floor obstructions but the potential exists for stacking Type B shipping containers to a second tier during actual transport vehicle loading and unloading procedures. This second tier stacking hazard is not a threat to Type B shipping containers. Waste container loads on forklifts may be required to be raised to heights sufficient to allow for stacking of the containers (*i.e.*, up to four high for drums and up to two high for boxes). Waste drum loads may be located on pallets containing up to 4 containers. A drum lifting device will be used to move materials into repackaging gloveboxes. These raised loads on forklifts or drum lifting devices present a potential energy hazard that could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to container drops and breach; and (2) spill of container contents following drop events.

Overhead lifting devices (*e.g.*, overhead bridge cranes, hoist) will be used in several waste management facilities to move heavy objects including waste containers. It is possible that a suspended load could be dropped onto a glovebox or on waste material container(s) resulting in a breach to material confinement. Such failures could result in a material spill and subsequent radiological and/or toxicological release. Drops of loads onto confined radioactive material containers are considered in the Safety Analysis as a spill initiator/precursor. The lifting devices are indirectly considered in the analysis of seismic events as part of the debris that may fall onto stored waste containers.

The raised or suspended loads/material hazard associated with the use of forklifts and drum handling devices is further evaluated and the protective features are identified in later sections of this report.

Stacked Waste Containers (Sub-hazard 8B)

Part of the waste management mission is to store on-site transportation approved shipping containers containing plutonium, uranium, and/or americium contaminated wastes. Waste container storage may require stacking of up to 4 drums or 2 boxes in some locations. The waste drums may be located on pallets containing up to 4 containers. These stacked waste containers present a potential energy hazard that could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to container falls and breach; and (2) spill of container contents following falling events. The stacked waste containers hazard is further evaluated and the protective features are identified in later sections of this report.

## 5.8 TOXIC, HAZARDOUS, OR NOXIOUS MATERIALS (HAZARD/ENERGY SOURCE 9)

General Industrial Chemicals, Bulk or Process Chemicals below Thresholds of Concern (Sub-hazard 9A)

General industrial chemicals and other non-radioactive bulk or process chemical inventories in waste management facilities consist of a wide variety of materials due to the numerous tenant activities that have been and/or continue to be conducted. Some chemicals are no longer being used and will be removed over time as excess chemicals. Some chemicals are currently being used as part of facility operations and tenant activities. Since the Safety Analysis would only be concerned with chemical inventories exceeding TQ or TPQ threshold quantities, chemicals that exist in quantities below the threshold quantities are considered a Standard Industrial Hazard. Bulk, process, and waste chemicals that exceed or have the potential to exceed a TQ or TPQ threshold quantity are addressed in Sub-hazard 9B below.

Protective features credited in the determination that general industrial chemicals, bulk chemicals, or process chemicals below thresholds of concern are Standard Industrial Hazards are:

- Containment – chemical packaging [INS]
- Physical barriers – chemical packaging [INS]

- Current configuration control – separation from radioactive materials [CONFIG, WMEP]
- Protective equipment – protective clothing, eyewash and safety showers, respirators [INS]
- Administrative – chemical inventory, area restrictions, area surveys, postings, maintenance work evaluation, training, work control [ORG, INS, PROC, TRAIN, TS&M, WORK]

Bulk, Process, or Waste Chemicals Exceeding Thresholds of Concern (Sub-hazard 9B)

Non-radioactive bulk, process or waste chemical inventories in waste management facilities potentially consist of a wide variety of materials due to the numerous tenant activities that have been and/or continue to be conducted. Some chemicals are no longer being used and will be removed over time as excess chemicals. Some chemicals are currently being used as part of facility operations and tenant activities. Chemical inventories exceeding TQ or TPQ threshold quantities have the potential to affect the IW, the CW, and the public in the event of an inadvertent or accidental release. Bulk, process, and waste chemicals that exceed or have the potential to exceed a TQ or TPQ threshold quantity are evaluated further in individual AB documents on a case-by-case basis.

RCRA Hazardous Waste (Sub-hazard 9C)

RCRA hazardous waste potentially includes toxic metals, corrosive liquids, and organic solvents in small quantities that present no potential safety or health hazard such as fire, explosion, or chemical exposure above the normal operating conditions in the work area. Information regarding containerized wastes is obtained from the Site-wide WEMS database or equivalent facility databases. Such databases contain characterization information on each waste container including: identification number, waste type, container type, IDC or WFC designation, assigned EPA waste codes, waste compatibility codes, and location by building and room. For containerized wastes characterized as RCRA hazardous, it is not always possible to determine exact chemical quantities since the actual chemical constituents are not always known and waste inventories continuously change. Since the Safety Analysis would only be concerned with waste chemical inventories exceeding TQ or TPQ threshold quantities, waste chemicals that exist in (or are thought to exist in) quantities below the threshold quantities are considered a Standard Industrial Hazard. Hazardous chemicals in RCRA waste containers that can be determined and that exceed a TQ or TPQ threshold quantity are addressed in Sub-hazard 9B above.

Protective features credited in the determination that RCRA hazardous waste is a Standard Industrial Hazard are:

- Containment – waste containers/packaging [INS]
- Physical barriers – waste containers/packaging [INS]
- Current configuration control – RCRA permit control requirements [WMEP]
- Protective equipment – protective clothing, eyewash and safety showers, respirators [INS]

- Administrative –postings, training, work control [ORG, INS, PROC, TRAIN, WORK]

Beryllium (Sub-hazard 9D)

Beryllium metal parts are located in multiple 55-gallon drums in Room 158 of Building 991 (classified vault). The amount of beryllium is greater than the RQ threshold of 10 pounds. Beryllium has no defined TQ or TPQ values. The only possible type of CW or public exposure is through inhalation. According to data in the Risk Assessment Information System (RAIS), a database maintained by the Oak Ridge National Laboratory, (Ref. 20), acute toxicity effects occur at concentrations above 100 grams of beryllium per cubic meter. Carcinogenic effects of beryllium inhalation are related to long-term (i.e., occupational) exposures. It is not expected that any accident involving beryllium would result in concentrations at the CW and public exceeding 100 $g/m^3$. Also, any exposure would be short-term. Therefore, the toxic, hazardous, or noxious chemical hazard associated with the beryllium inventory is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that beryllium is a Standard Industrial Hazard are:

- Containment – current material form control, waste containers/packaging [INS, WMEP]
- Physical barriers – waste containers/packaging [INS]
- Protective equipment – protective clothing [INS]
- Administrative – area restrictions, area surveys, postings, maintenance work evaluation, training, work control [INS, PROC, TRAIN, TS&M, WORK]

Asbestos (Sub-hazard 9E)

Containerized wastes with asbestos may be generated in the waste management facilities. Asbestos currently exists in some floor tiling and potentially exists in some ceiling tiles and room partitions or walls. The exact amount of asbestos, particularly friable asbestos, is not known but the friable asbestos is assumed to exceed the RQ threshold of one pound. Asbestos has no defined TQ or TPQ value. The dispersibility of asbestos in the floor tiling and ceiling tiles and in waste containers is currently limited, but the asbestos does pose a risk to the IW if the material is disturbed. According to RAIS (Ref. 21), the acute toxicity effects associated with inhalation of asbestos are temporary breathing difficulties. These breathing difficulties result from "high concentrations" in an occupational setting. According to RAIS, subchronic and chronic toxicity effects are due to long-term exposure (at least six months) in an occupational setting. Carcinogenic effects are also related to long-term exposures. Any CW or public exposure to asbestos would be short-term and would only be expected, at worst, to cause the acute toxicity effects described above. Therefore, the chemical hazard associated with asbestos is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that asbestos is a Standard Industrial Hazard are:

- Containment – current material form control, waste containers/packaging [INS, WMEP]
- Physical barriers – waste containers/packaging [INS]
- Protective equipment – protective clothing, respirators [INS]
- Administrative – area restrictions, area surveys, postings, maintenance work evaluation, training, work control [ORG, INS, PROC, TRAIN, TS&M, WORK]

Polychlorinated Biphenyls (PCBs) (Sub-hazard 9F)

Containerized wastes with TSCA-regulated PCBs may be generated in waste management facilities but a permit must be obtained for a staging area location prior to generating the waste. Controls mandated by TSCA regulations are credited as preventive and mitigative measures before the PCBs are transferred to a permanent TSCA storage area different from the generating facility. PCBs currently exist in the fluids of some transformers and potentially exists in some fluorescent lighting fixtures. The exact quantity of PCBs in the waste storage facilities is not known, but it is expected that the total quantity in a single facility exceeds the RQ of one pound. PCBs have no defined TQ or TPQ values. The PCBs that may exist in the lighting fixtures are not readily dispersible but the transformer fluid PCBs can be dispersed. PCBs in waste containers could be released during a fire or spill. A fire involving PCBs would volatilize some of the PCBs and allow them to be transported away from the immediate area. The volatilized PCBs could result in CW or public exposure through inhalation. According to RAIS (Ref. 22), acute toxicity effects expected include anorexia, nausea, edema, abdominal pain, ocular discharge, and burning sensations in the skin and eyes, although no specific data exists. Subtonic toxicity effects are documented as mild to moderate chlorine in 50% of workers exposed to 0.1 mg/m$^3$ for an average of 14.3 months. Suspected carcinogenic effects of PCB inhalation are related to long-term (i.e., occupational) exposures. Exposure of both the CW and public would be short-term. Due to the low CW and public consequences associated with a chemical release of PCBs, the chemical hazard associated with PCBs is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that PCBs are a Standard Industrial Hazard are:

- Containment – current configuration control, waste containers [INS, CONFIG, WMEP]
- Physical barriers – waste containers/packaging [INS]
- Protective equipment – protective clothing [INS]
- Administrative – postings, maintenance work evaluation, training, work control [INS, PROC, TRAIN, TS&M, WORK]

Lead (Sub-hazard 9G)

Containerized wastes with lead may be generated in waste management facilities but will require a RCRA satellite storage area for temporary staging. Controls mandated by RCRA regulations are credited as preventive and mitigative measures before the waste lead is transferred to a permanent RCRA storage area different from the generating facility. In addition, lead exists as shielding for various NDA equipment, in some painted surfaces (*i.e.*, lead-based paints), and in some batteries (see *Batteries (Sub-hazard 9H)*) used in waste management facilities. The lead used as shielding and in batteries and paint is relatively difficult to disperse, but the potential exists that lead in painted surfaces could become dispersible as the paint peels from the surface as it is disturbed. The exact amount of lead in a single facility, particularly dispersible lead, is not known but the lead is assumed to exceed the RQ threshold of one pound. Since lead has no defined TQ or TPQ value, it can be argued that the dominant risk from this hazardous material is to the IW and/or the environment and the material does not pose a significant risk to the CW or the public. The dispersibility of the lead is currently limited, but the lead may pose a risk to the IW, if the material is disturbed. Due to the lack of dispersibility of the material, the toxic, hazardous, or noxious chemical hazard associated with lead is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that lead is a Standard Industrial Hazard are:

- Containment – current configuration control, waste containers/packaging [CONFIG, INS, WMEP]
- Physical barriers – current configuration control, waste containers/packaging [CONFIG, INS]
- Protective equipment – protective clothing [INS]
- Administrative – area restrictions, area surveys, postings, maintenance work evaluation, training, work control [ORG, INS, PROC, TRAIN, TS&M, WORK]

Batteries (Sub-hazard 9H)

Batteries containing lead exist in waste management facilities. In addition, a RCRA satellite storage areas can be used to accumulate spent nickel-cadmium batteries. Controls mandated by RCRA regulations are credited as preventive and mitigative measures before the nickel-cadmium batteries are transferred to a permanent RCRA storage area different from the generating facility. The dispersibility of the hazardous constituents of the batteries is relatively low and these hazardous materials do not pose a significant risk to the CW and the public. Due to the lack of dispersibility of the hazardous materials found in batteries, the toxic, hazardous, or noxious chemicals hazard associated with batteries are considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that batteries are a Standard Industrial Hazard are:

- Containment – component package, waste containers/packaging [INS, WMEP]
- Physical barriers – component package, waste containers/packaging [INS, WMEP]
- Protective equipment – protective clothing, eyewash & safety showers [INS]

- Administrative – component inspections, training, work control [INS, PROC, TRAIN, WORK]

Diesel Fuel (Gasoline) (Sub-hazard 9I)

Diesel fuel or gasoline currently exists in diesel generator day tanks and in some gasoline powered equipment (*e.g.*, drum crusher gasoline tank) used at waste management facilities. Since diesel fuel and gasoline have no defined RQ, TQ, or TPQ values, it can be argued that the dominant risk, if any, from these chemicals is to the IW and/or the environment and the chemicals do not pose a significant risk to the CW or the public. The risks associated with the use of diesel fuel or gasoline is a commonly accepted risk by the public. Due to the low CW and public consequences associated with a chemical release, the toxic, hazardous, or noxious chemical hazard associated with diesel fuel and gasoline is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that diesel fuel is a Standard Industrial Hazard are:

- Physical barriers – approved storage tanks [INS]
- Administrative – postings, training, work control [INS, PROC, TRAIN, WORK]

## 5.9 INADEQUATE VENTILATION (HAZARD/ENERGY SOURCE 10)

Unventilated Areas (Sub-hazard 10A)

This hazard consists of areas with limited air interfaces to the outside. Stagnation of the air in unventilated areas (including tunnels) is expected but no mechanisms exist for air displacement, oxygen depletion, or noxious gas entry. The major concerns would deal with the buildup of radon gas and/or asbestos fibers.

The stagnation of air in confined areas can lead to IW injuries due to asphyxiation or noxious gas inhalation, in some cases. The stagnant air has no impact on waste storage containers and poses no risk to the CW and the public. Therefore, the inadequate ventilation hazard associated with unventilated tunnels and areas is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that unventilated tunnels and areas are a Standard Industrial Hazard are:

- Monitoring and localized ventilation – area surveys/monitoring, current configuration control [CONFIG, INS, WMEP]
- Physical barriers – locked doors, controlled access [ORG, INS]
- Protective equipment – breathing air [INS]
- Administrative – area restrictions, area surveys, postings, training, work control [ORG, INS, PROC, TRAIN, WORK]

## 5.10 MATERIAL HANDLING (HAZARD/ENERGY SOURCE 11)

Handling, Transfer, and Shipment of Waste Containers (Sub-hazard 11A)

Part of the waste management mission is to receive, handle, transfer, and ship approved shipping containers containing plutonium, uranium, and/or americium contaminated wastes. The handling of waste containers within a facility supports waste storage, glovebox operations including bagin and bagout, and drum preparation for repackaging. Waste materials will be bagged into and out of a glovebox during repackaging activities. Materials generated during drum coring operations must be handled and bagged out of a glovebag. Also, HEPA filters in the exhaust system for repackaging areas are potentially contaminated and will be changed out using a glovebag. As part of waste repackaging activities, waste drums must be moved and prepared for introduction into a repackaging glovebox.

The conduct of material handling activities presents potential hazards that could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to container breach; (2) spill of container contents due to impact, and (3) spill of container contents following puncture events. Material handling hazards are further evaluated under the *Vehicles, Material Handling Equipment* hazard and the *Suspended Loads/Material* hazard discussed in Section 5.6, *Kinetic Energy (Hazard/Energy Source 7)*, and the *Raised or Suspended Loads/Material* hazard discussed in Section 5.7, *Potential Energy (Hazard/Energy Source 8A)*.

## 5.11 UNKNOWN OR UNMARKED MATERIALS (HAZARD/ENERGY SOURCE 12)

Waste to be Repackaged (Sub-hazard 12A)

Some wastes require repackaging due to unknown objects being identified in the waste container. Unknown contents may include chemicals that could react if mixed with incompatible materials during repackaging operations. The potential effects of the reactive chemicals are considered to be bounded by the incompatible chemical hazard. Incompatible chemicals can react independent of repackaging operations. Unknown wastes to be repackaged could result in (1) fires in enclosures, and (2) spills from breach of enclosures due to inadvertent chemical reactions. The waste to be repackaged hazard is further evaluated under the *Incompatible Chemical* hazard discussed in Section 5.12, *Other Hazards (Hazard Energy Source 13B)*.

## 5.12 OTHER HAZARDS (HAZARD/ENERGY SOURCE 13)

Flammable Gas Generation in Metal Waste Containers (Sub-hazard 13A)

Part of the waste management mission is to receive, store, transfer and ship approved metal, sealed shipping containers containing plutonium, uranium, and/or americium contaminated wastes. The radioactive decay of the radiological waste material has the potential to interact with hydrogenous waste materials producing hydrogen and oxygen gases. Hydrogen and oxygen generation in drums could lead to hydrogen explosion accidents (*i.e.*, container explosions). Based on the explosive nature of hydrogen, the hydrogen gas generation hazard bounds the generation of other gases that could overpressurize and breach a container (*i.e.*, hydrogen gas pressure could be significantly lower than waste container internal failure pressure and still lead to container failure as a result of the rapid combustion of the hydrogen).

The Los Alamos Technology Office report, *Plutonium and Uranium Solutions Safety Study* (Ref. 23), documents some early effort to understand the radiolytic hydrogen hazard in drums and tanks. USQDs that have evaluated the hydrogen explosion risk associated with the handling and storage of drums include: Movement *of Drums Containing Unvented Hydrogen Gas Within Building 371*, USQD-371-95.0170-MDT (Ref. 24); and *Movement and Storage of 55 Gallon Drums in Unfiltered Areas Suspected of Having Hydrogen Accumulated in Drum Space*, USQD-RFP-95.0180-DSR (Ref. 25). Radiolytic hydrogen generation has been evaluated in several technical reports including: *Evaluation of Residue Drum Storage Safety Risks* (Ref. 26); and *Safety Analysis of Hydrogen Generation in Drums Containing Plutonium Contaminated Materials* (Ref. 27). Calculations to predict pressure rise in unvented drums due to radiolytic gas generation are contained in Nuclear Safety Calculation, *Building 371/374 BIO Support Calculation - Explosions*, 96-SAE-025 (Ref. 28). Hydrogen explosions in metal waste containers generate sufficient pressure to result in the loss of the container lid. A concurrent fire involving the waste container contents is judged not to occur following the overpressurization and lid loss due to the rapidity and low energy of the excursion (Ref. 29). The hydrogen generation in metal waste containers hazard is further evaluated and the protective features are identified in later sections of this report.

Incompatible Chemicals (Sub-hazard 13B)

Wastes that are received, stored, prepared for repackaging, and repackaged may contain incompatible chemicals that could react resulting in a hazardous material release. Incompatible chemicals could result in (1) fires internal to waste containers leading to container failure, (2) reactions internal to waste containers leading to container pressurization and potential explosion, (3) reactions internal to waste containers leading to filter vent corrosion and subsequent failure, (4) reactions internal to a repackaging glovebox leading to glovebox pressurization and potential "explosion" or failure, (5) fires in a repackaging glovebox, (6) spills from corrosive reactions involving contaminated materials leading to enclosure failures, and (7) fires in the repackaging area impacting open containers. The incompatible chemical hazard is further evaluated and the protective features are identified in later sections of this report.

Battery Charging Station (Sub-hazard 13C)

Battery charging stations exist throughout the waste management facilities to support the re-charging of electric forklift batteries. The battery charging stations present thermal and explosion hazards that can potentially result in the initiation of a fire, burn personnel, and injure personnel from explosion-generated missiles. No radioactive materials are located in close proximity to charging stations. Fires initiated by battery charging are expected to be confined due to the separation between the charging stations and probable combustible loads. Explosion generated missiles with sufficient energy to impact waste containers are also expected to be confined to the battery charging station due to the separation distance.

Due to the location of the battery charging stations relative to any sources of radioactive material, the thermal and explosion hazards associated with the battery chargers are considered Standard Industrial Hazards and will not be further evaluated.

Protective features credited in the determination that battery charging stations are a Standard Industrial Hazard are:

- Current configuration control – separation from hazardous materials [CONFIG, WMEP]
- Combustible control - separation from combustibles [FIRE]
- Physical barriers – component enclosures [INS]
- Protective equipment – protective clothing, eyeshields [INS]
- Administrative – component inspection, work control, postings, training, lockout/tagout [INS, PROC, TRAIN, WORK]

Structure Degradation and Leakage (Sub-hazard 13D)

This hazard/energy source is applicable to the Building 991 complex only.

The Building 991 Complex has three sets of tunnels connecting Building 991 to Buildings 996, 997, 998, and 999. Corridor A connects to Building 998 (Room 300). Corridor B connects directly to Building 996 and Corridor B. Corridor B connects to Corridor C and Buildings 997 and 999. Buildings 996 and 998 (Room 300) are areas that are currently designated for waste container storage.

The degradation of the tunnels could lead to failure of the tunnel roof with subsequent influx of soil from above. The collapse of a tunnel could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to container breach from structure impacts; (2) spill of container contents following container breach from structure impacts; and (3) spill of container contents following puncture events as a result of structure impacts. The leakage of tunnels, other than acting as a precursor to tunnel collapse, should pose no risk to the IW (other than presenting slippery surfaces), the CW, or the public due to the limited amount of water involved in the leakage (the tunnels are above the aquifer and leakage is a result of rain or snow melt percolating through the soil). The tunnel degradation and leakage hazard is further evaluated and the protective features are identified in later sections of this report.

Diesel Fuel (Gasoline) Storage Tank Combustibles (Sub-hazard 13E)

Some waste management facilities are supported by backup power diesel generators that utilize day tanks (typical size of 180-gallon) and above ground fuel supply tanks (typical size of 1,000-gallon). Also, gasoline powered equipment (*e.g.*, a drum crusher utilizes a small gasoline fuel tank to run the drum crusher motor) may be used at some of the waste management facilities. Additional diesel fuel quantities are associated with transport vehicles, which are discussed in Section 4.1.4, *Thermal Energy*, Sub-hazard 5H. Fires associated with the diesel fuel supplies for the diesel generators could impact the electric power supply to supported waste management facilities, however the loss of electric power is dominated by other electrical system failure modes. Fires impacting backup power supplies would have little contribution to the overall frequency associated with the loss of power to waste management facilities. Fires associated with the gasoline fuel supply for gasoline powered equipment would be minor due to the quantity of fuel present. Due to the location of fuel supplies relative to any sources of radioactive material and the frequency dominance of other initiators dealing with loss of electric power, the combustible material hazard associated with diesel fuel (gasoline) storage tanks is considered a Standard Industrial Hazard and will not be further evaluated.

Protective features credited in the determination that diesel and gasoline fuel storage tanks are Standard Industrial Hazards are:

- System maintenance – maintenance of tank barriers [TS&M]
- Current configuration control - separation from hazardous materials [CONFIG, WMEP]
- Physical barriers – separate facilities, locked facilities [ORG, CONFIG]
- Administrative – system inspection/monitoring, maintenance work evaluation, work control, postings, training [ORG, INS, PROC, TRAIN, TS&M, WORK]

Floor Loading (Sub-hazard 13F)

The potential exists that the storage of waste containers up to a fourth tier could exceed the design loading of the waste management facility floor if the original design was developed for floor loads that are significantly lower than current, drum storage loads. The failure of floors due to waste container loads could result in: (1) exposure of pyrophoric waste metal to atmosphere with subsequent fires due to container breach; and (2) spill of container contents following container falls. Due to the uncertainty associated with the load capacity of some floors in the waste management facilities, the floor loading hazard is further evaluated and the protective features are identified in later sections of this report.

Combustibles (Sub-hazard 13G)

The operation of waste management facilities will include the introduction, staging, use, and storage of various combustible materials. Examples of combustibles that may be located in the facilities at various times include: (1) wooden pallets from the receipt of empty waste drums; (2) combustible/flammable liquids stored in fire rated cabinets or in other containers for use by tenant activities (*e.g.*, developer and fixer solutions to be used by NDT activities); (3) construction materials (*e.g.*, scaffolding); and (4) general Office Area combustibles (*e.g.*, furniture, paper, plastics). The presence of combustibles does not necessarily present an immediate hazard but combustible loading in a facility can increase the consequences associated with fires and can lead to facility fire propagation if ignited. Waste container storage areas are not generally used for the accumulation or storage of combustible materials but transient combustibles may be temporarily located in these areas, and non-waste storage area combustible loading and subsequent fires may impact contiguous waste storage areas. The combustibles hazard is further evaluated and the activity interactions and protective features are identified in later sections of this report.

Natural Phenomena or External Events (Sub-hazard 13H)

Natural Phenomena or External Event Induced Fires - Waste management facilities will contain various combustible materials and ignition sources during operations. It is possible that natural phenomena or external events could result in facility fires by impacting these combustibles and ignition sources. Seismic events may result in natural gas line failure (mobile flammable material travels to an ignition source), electric power system short circuits (ignition source that can act on nearby combustibles), or breach of flammable liquid containers (mobile flammable material travels to an ignition source) that subsequently leads to a fire. Lightning (a natural phenomena ignition source) may result in electric power system short circuits (ignition source that can act on nearby combustibles) or may act directly on combustibles that can lead to a fire. Aircraft crash (external event) can directly lead to a fire as a result of the aircraft fuel and heated materials involved in the crash. Range fires impacting vegetation near a waste management facility can directly lead to fire impacting external combustibles near the facility. The natural phenomena or external event induced fires hazard is further evaluated and the protective features are identified in later sections of this report.

Natural Phenomena or External Event Induced Spills - Waste management facilities will contain radioactive materials during operations. It is possible that natural phenomena or external events could result in spills and punctures of the radioactive material containers by directly or indirectly impacting the containers. Seismic events may result in toppling stacked waste containers, debris impacts on containers from ceiling component failures (*e.g.*, lighting, ducting, cranes) during the seismic event, or structure impacts on containers from seismic-induced facility collapse that subsequently leads to a spill or puncture. High winds, tornadoes, and heavy snow may result in structure impacts on containers from partial facility collapse due to the loss of a load bearing wall (*i.e.*, static load from wind exceeds design capacity of a wall) or due to the failure of the roof (*i.e.*, static load of the snow exceeds design capacity of the roof) that subsequently leads to a spill or puncture. In addition, tornadoes may result in debris impacts on containers by tornado-driven missiles that subsequently lead to a spill or puncture. Heavy rains, flooding (internal or external), and freezing induced internal flooding may result in toppling stacked waste containers (*i.e.*, flowing water during flood carries debris that impacts stacked containers) or structure impacts on containers from partial facility collapse due to the loss of a load bearing wall (*i.e.*, waters erode soils near wall footings) that subsequently leads to a spill or puncture. Aircraft crash (external event) may result in toppling stacked waste containers, debris impacts on containers from aircraft parts, or structure impacts on containers from partial facility collapse due to the aircraft penetration of a load bearing wall that subsequently leads to a spill or puncture. The natural phenomena or external event induced spills hazard is further evaluated and the protective features are identified in later sections of this report.

Natural Phenomena or External Event Induced Explosions - Waste management facilities will contain potentially explosive materials and potentially explosive waste containers during operations. It is possible that natural phenomena or external events can result in facility explosions (with subsequent material fires) by releasing potentially explosive materials. Seismic events and aircraft crashes may result in natural gas line failure (release of potentially explosive material) due to failure of line or boiler supports or failure of any flammable gas containers used by the facility (*i.e.*, propane gas cylinders used during construction or maintenance activities) due to structural impacts from facility failure or from aircraft debris. High winds, tornadoes, and heavy snows may result in structure impacts on flammable gas containers used by the facility (*i.e.*, propane gas cylinders used during construction or maintenance activities) from partial facility collapse due to the loss of a load bearing wall (*i.e.*, static load from wind exceeds design capacity of a wall) or due to the failure of the roof (*i.e.*, dynamic load from wind/tornado or static load of the snow exceeds design capacity of the roof) that subsequently leads to an explosion. In addition, high winds or tornadoes may result in debris impacts on natural gas lines or boilers by wind/tornado-driven missiles that subsequently leads to a release of the gas. Lightning (a natural phenomena ignition source) may act directly on potentially explosive materials (*i.e.*, striking natural gas lines or propane cylinders) that can lead to an explosion. The natural phenomena or external event induced explosions hazard is further evaluated and the protective features are identified in later sections of this report.

Natural Phenomena or External Event Induced Criticalities - Waste management facilities will contain radioactive materials during operations. It is possible that natural phenomena or external events can result in criticalities (with subsequent spills or material fires) by rearranging radioactive material containers. Seismic events and aircraft crashes may result in toppling stacked waste containers and/or rearranging the container configurations that subsequently leads to a criticality. Heavy snows may result in structural failures leading to toppling stacked waste containers, rearranging the container configurations, that subsequently leads to a criticality. Heavy rains, flooding (internal or external), and freezing induced internal flooding may result in toppling stacked waste containers (*i.e.*, flowing water during flood carries debris that impacts stacked containers), rearranging the container configurations and adding moderation (*i.e.*, water acts as a moderator) that subsequently leads to a criticality. The natural phenomena or external event induced criticalities hazard is further evaluated and the protective features are identified in later sections of this report.

## 5.13 CREDITED PROTECTIVE FEATURES FOR STANDARD INDUSTRIAL HAZARDS

The hazard identification process identified 45 hazards or energy sources for waste management facilities. Of the 45 hazards, 23 hazards or energy sources were characterized as Standard Industrial Hazards. Protective features for these 23 hazards were identified and fall into two general classes: (1) protective features to ensure that the hazard remains a Standard Industrial Hazard, termed Hazard Controls; and (2) protective features associated with worker protection against the Standard Industrial Hazard, termed IW Protection. Protective features placed in the Hazard Control class of credited protective features are carried forward into the *Waste Management Facilities Technical Safety Requirements*.

The identified protective features associated with each Standard Industrial Hazard, as listed in Table 5-4, are related to Site SMPs.



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# 6. HAZARD EVALUATION AND SELECTION OF ACCIDENT SCENARIOS REQUIRING FURTHER ANALYSIS

## 6.1 HAZARD EVALUATION

Of the 45 identified hazards and energy sources, 22 hazards or energy sources required further evaluation. Eighteen of these 22 hazards or energy sources are considered in this NSTR as accident initiators or precursors. The *Thermal Energy: Transport Vehicles* hazard (Hazard 5H) has been evaluated in Volume I, Chapter 8, *Transportation Safety Analysis*, of the Site SAR (Ref. 2) and is not discussed further in this NSTR. Likewise, the *Toxic, Hazardous, or Noxious Chemicals: Bulk, Process, or Waste Chemicals Exceeding Thresholds of Concern* hazard (Hazard 9B) is addressed in individual facility AB documents on a case-by-case basis. The *Material Handling: Handling, Transfer, and Shipment of Waste Containers* hazard (Hazard 11A) is evaluated under the *Vehicles, Material Handling Equipment* hazard (Hazard 7A), the *Suspended Loads/Material* hazard (Hazard 7C), and the *Raised or Suspended Loads/Material* hazard (Hazard 8A). The *Unknown or Unmarked Materials: Waste to be Repackaged* hazard (Hazard 12A) is evaluated under the *Incompatible Chemical* hazard (Hazard 13B). Table 6-1 presents the 18 hazards or energy sources from Table 5-4 that were considered in the determination of representative accident scenarios discussed later in this NSTR. The numerical codes associated with each hazard shown in Table 6-1 relate back to the general hazard category (*e.g.*, Radioactive Materials, Kinetic Energy) and the specific hazards under each category. For example, Hazard 7A corresponds to specific hazard, *Vehicles, Material Handling Equipment*, under general hazard category 7, *Kinetic Energy*.

**Table 6-1** Waste Management Facility Hazards and Energy Sources to be Further Evaluated

| # | HAZARD/ENERGY SOURCE | # | HAZARD/ENERGY SOURCE |
|---|---|---|---|
| 4A | Category I and II SNM | 4B | Containerized Radioactive Waste |
| 4C | In Process Radioactive Waste and/or Newly Generated Radioactive Waste | 5B | Flammable Gases |
| 5C | Hot Work (not involving flammable gases) | 5D | Pyrophoric Materials |
| 5E | Electric Power Systems | 6C | Compressed Gas Cylinders |
| 7A | Vehicles, Material Handling Equipment | 7C | Suspended Loads/Materials (kinetic energy) |
| 8A | Raised or Suspended Loads/Materials (potential energy) | 8B | Stacked Waste Containers |
| 13A | Flammable Gas Generation in Metal Waste Containers | 13B | Incompatible Chemicals |
| 13D | Structure Degradation and Leakage | 13F | Floor Loading |
| 13G | Combustibles | 13H | Natural Phenomena or External Events |

The hazards of most interest, in Table 6-1, are Hazard 4A, *Category I and II SNM*, Hazard 4B, *Containerized Radioactive Waste*, and Hazard 4C, *In Process Radioactive Waste and/or Newly Generated Radioactive Waste*. The remaining hazards and energy sources either act on these hazards (*e.g.*, Hazard 7A, *Vehicles, Material Handling Equipment*) or are subsets of these hazards (*e.g.*, Hazard 5D, *Pyrophoric Materials*). In support of the hazard evaluation process and determination of representative accident scenarios, a logic diagram shown in Figure 6-1, as described below, was developed displaying the manner in which each of the remaining hazards and energy sources act on Hazard 4A, Hazard 4B, and Hazard 4C resulting in a radiological release.

The radioactive material hazards are contained or confined in various SNM and waste containers or in confinement enclosures (*e.g.*, secondary confinement such as repackaging gloveboxes, contamination cells, etc.). The material has an increased hazard to the IW and is only a hazard to the CW and the public when it becomes unconfined due to a container failure, confinement enclosure failure, or when a criticality involving the material occurs. The criticality case can result in the release of radioactive material that is not currently found in the containers but is generated during the criticality event (*i.e.*, fission products). However, the criticality event can also result in container failure due to over-pressurization of the container. By identifying manners in which containers or enclosures can fail, mechanisms for radioactive material release can be determined.

A radiological release logic diagram shown in Figure 6-1 identifies two failure types that can lead to a radiological release: (1) container failure (*e.g.*, failure of waste containers) and (2) confinement enclosure failure (*e.g.*, failure of an RT glovebox or contamination cell). Distinctions between these two failure types are made because some mechanisms for failure are different based on whether or not the MAR is considered confined (containerized) or "loose" within a confinement enclosure during a waste management activity. Container failure is associated with waste management activities in which waste containers can be accidentally breached but not intentionally opened. Therefore, container failure is applicable to SH, CR, and RA. Confinement enclosure failure is associated with activities that involve intentional opening of waste containers, for example, during sampling, repackaging, treatment, and generation. Confinement enclosure failure is therefore applicable to CC, RT, and GN.

The radiological release logic diagram presents a logical connection between the 15 applicable hazards and energy sources requiring further analysis (Hazard 4A, Hazard 4B, and Hazard 4C are excluded) and a radiological release. The far left of the logic diagram begins with the undesired radiological release event. The second column identifies the failure type, either container failure or loss of confinement. Columns three and four identify basic release mechanisms and specific release mechanisms respectively. It is assumed that no basic release mechanisms for container/confinement enclosure failure exist other than mechanically, chemically, thermally, and overpressure-induced. The fifth column relates hazards and energy sources to the basic and specific release mechanisms leading to the radiological release event. Intentional opening of waste containers leading to a release is considered in the confinement failure portion of the logic diagram. Having defined a relationship between facility hazards/energy sources and release mechanisms leading to container/confinement enclosure failure and a radioactive material release, it is possible to begin release scenario development. The final column of the logic diagram identifies scenarios that require further evaluation.

The container failure portion of the radiological release logic diagram applies only to metal waste containers and POCs. POCs are susceptible to failure, resulting in a radiological release, only if an aircraft crashes into the facility. Therefore, the only failure path applicable to POCs is Container Failure/External/Mechanical/Impact. Type B SNM shipping containers are excluded because (1) they are susceptible to failure only if an aircraft crashes into the facility, (2) they are only stored in Building 991, and (3) aircraft crashes into areas of Building 991 where Type B SNM shipping containers are stored will not perforate the structure (Ref. 30). Wooden waste crates are excluded because it is assumed that they will be prohibited from use in waste management facilities. The following assumptions are made in the development of the logic diagram:

(1) The Container Failure/Internal/Mechanical failure path was not analyzed because:

- few materials in radioactive material containers exist that can mechanically fail a container from the inside.

(2) The Container Failure/Internal/Thermal failure path was not analyzed because:

- the internal fire must be sufficiently hot to melt through metal; and
- few combustibles associated with materials in radioactive material containers exist at the Site with sufficient combustion temperature to melt metal.

(3) The Container Failure/Internal/Overpressure/Chemical Reaction failure path was not analyzed because:

- the chemical reaction must be sufficiently fast to generate significant quantities of gas rapidly;
- few chemical reactions associated with materials in waste exist at the Site with significant fast gas generation capabilities;
- incompatible chemicals inside waste containers are prohibited; and
- a container overpressure condition resulting from a chemical reaction is assumed to be bounded by the ignition of hydrogen gas, which will forcefully eject a portion of the contents.

(4) The Container and Confinement Enclosure Failure/Chemical failure paths were not analyzed because:

- the chemical failure mechanism is relatively slow ;
- there is significant potential for discovery prior to failure; and
- highly corrosive liquids in container SH and RT areas are prohibited without full secondary containment of the liquid being in place.

(5) The Confinement Enclosure Failure/Overpressure failure path was not analyzed because:

- the chemical reaction must be sufficiently fast to generate significant quantities of gas rapidly;
- few chemical reactions associated with materials in waste exist at the Site with significant fast gas generation capabilities;
- incompatible chemicals inside waste containers are prohibited; and
- a confinement enclosure overpressure condition resulting from a chemical reaction is assumed to be bounded by the ignition of hydrogen gas, which will forcefully eject a portion of the contents.

| Event | Failure Type | Basic Release Mechanism | Specific Release Mechanism | Hazard/Energy Source | | Scenarios Requiring Further Evaluation |
|---|---|---|---|---|---|---|
| Radiological Release | Container Failure: Internal Mechanisms | Mechanical | *not analyzed* | | | |
| | | Chemical | Corrosion | 13B | ⇒ | **Spill: Corrosion** |
| | | Thermal | *not analyzed* | | | |
| | | Overpressure | Chemical Reaction | *not analyzed* | | |
| | | | Explosion | 13A | ⇒ | **Explosion: Container** |
| | | | Criticality | 5B, 8C, 13D, 13F, 13H | ⇒ | **Criticality** |
| | Container Failure: External Mechanisms | Mechanical | Drop/Fall | 8A; 8C and [7A or 13H] | ⇒ | **Spill: Drop/Fall** |
| | | | Puncture | 6C, 7A, 13D, 13F, 13H | ⇒ | **Spill: Puncture** |
| | | | Impact | 7A, 13D, 13F, 13H | ⇒ | **Spill: Impact** |
| | | Chemical | *not analyzed* | | | |
| | | Thermal | Fire | [5B or 13G] and [5C or 5E or 13H] | ⇒ | **Fire: Facility (1 MW/4 MW); Fire: Container** |
| | | Overpressure | Explosion | 5B and [5C or 5E] | ⇒ | **Explosion: Facility** |
| | Confinement Enclosure Failure | Mechanical | Impact | 7A, 7C, 8A, 13H | ⇒ | **Spill: Impact** |
| | | | Puncture | 5B, 6C, 7A, 13H | ⇒ | **Spill: Puncture** |
| | | Chemical | *not analyzed* | | | |
| | | Thermal | Fire | [5D or 5E or 13B or 13H] and 13G | ⇒ | **Fire: Confinement Enclosure** |
| | | Overpressure | *not analyzed* | | | |

**HAZARD/ENERGY SOURCE KEY**

| | | | | | |
|---|---|---|---|---|---|
| 5B | Flammable Gases | 7A | Vehicles, Material Handling Equipment | 13B | Incompatible Chemicals |
| 5C | Hot Work (not involving flammable gases) | 7C | Suspended Loads/Materials (kinetic energy) | 13D | Structure Degradation |
| 5D | Pyrophoric Materials | 8A | Suspended Loads/Materials (potential energy) | 13F | Floor Loading |
| 5E | Electric Power System | 8C | Stacked Waste Containers | 13G | Combustibles |
| 6C | Compressed Gas Cylinders | 13A | Flammable Gas Generation in Metal Waste Containers | 13H | NPH/EE |

**Figure 6-1** Radiological Release Logic Diagram

## 6.2 ACCIDENT SCENARIOS REQUIRING FURTHER ANALYSIS

The selection of accident scenarios identifies those scenarios that must be further evaluated in the accident analysis. The logic diagram in Figure 6-1 in conjunction with previous hazard and accident analyses, specifically the Buildings 440 PSAR, Building 569 BIO, and the Building 991 FSAR (Refs. 31, 32, and 33), have identified eight general types of accident scenarios resulting in either container failure or loss of confinement:

- container spill
- confinement enclosure spill
- facility fire
- confinement enclosure fire
- container fire
- container explosion
- facility explosion
- criticality

These eight general types of scenarios may be initiated by internal, external, and natural phenomena events. There may be multiple specific accident scenarios identified within each general type of accident scenario to cover variations in initiating events within a general scenario type.

The accident scenario types are described below as they relate to the six waste management facility activity modules (SH, CC, CR, RT, GN, RA) defined in Section 1.4 of this NSTR. Three scenario types, container spills, container explosions, and facility fires, are postulated to occur during SH activities. Two scenario types, spills due to loss of confinement and confinement enclosure fire scenarios, are postulated to occur during RT activities. Two scenario types, container fires (due to direct flame impingement) and facility explosions are postulated to occur during RA. Criticality events are postulated to occur during CR activities that involve unassayed waste containers. Criticalities are considered *incredible* during all waste management facility activities involving assayed waste containers (*i.e.*, the radioactive material quantities are known). Criticality events are not evaluated in this NSTR revision.

### 6.2.1 Storage and Handling (SH) Accident Scenarios

The three accident scenario types applicable to SH activities are expanded in Figure 6-1 based on specific initiators and release mechanisms (*e.g.*, corrosion, drop/fall, puncture, impact, explosion, etc.). By considering specific initiators and release mechanisms, the number of closed waste containers involved in a specific scenario type can be determined. For example, a spill due to internal corrosion typically affects a single metal container while a spill resulting from a drop/fall can involve up to four drums on a single pallet. Additionally, by expanding the scenarios they can be related to specific SH sub-activities (*e.g.*, punctures occur most often during forklift operations while impacts occur most often when containers are in storage). Assessment of the three accident types applicable to SH activities resulted in the identification of eight unique accident scenarios that are carried forward and further evaluated in Section 8, *Storage and Handling (SH) Accident Analysis*, of this NSTR. These eight scenarios are listed and described in

Table 6-2. Section 8, *Storage and Handling (SH) Accident Analysis*, examines these accident scenarios considering container type (*e.g.*, Type B shipping containers, POCs, metal TRU waste containers, and metal LLW containers), confinement (*e.g.*, glovebox, contamination cell, Perma-Con, baghouses, glovebags, etc.), waste type (*e.g.*, LLW, TRU), specific release mechanism, MAR quantity (based on container limits), and damage ratio (based on accident progression). Based on further examination of the eight accident scenarios listed in Table 6-2, the most representative scenarios associated with SH activities are analyzed to determine accident frequencies, consequences, and risk classes.

**Table 6-2** Storage and Handling (SH) Accident Scenarios

| Scenario Type | Description |
|---|---|
| FIRE | FACILITY FIRE: SMALL Transient combustible materials (*e.g.*, plywood, wooden pallets, flammable/combustible liquids, etc.) may be present or stored in waste management facilities. If combustible materials are inadvertently stacked against or are in close proximity to waste containers and are ignited, several waste containers (three waste drums or one metal waste box) can be exposed to enough thermal energy to cause lid or lid seal failure and venting of radioactive materials. Small fire scenarios may not be of sufficient size to activate an operable automatic sprinkler system (if present in the facility). Small fire scenarios are judged to be *anticipated* events without prevention. |
| FIRE | FACILITY FIRE: LARGE In the event that facility combustible loading increases above that involved in a small fire scenario, a larger fire can result impacting additional waste containers beyond those involved in a small fire scenario (postulated to be nine waste drums or two metal waste boxes). Additional combustible loading may include materials present in office areas that are adjacent to waste storage areas, facility construction materials that are not fire resistant, and an excess amount of transient combustibles. Large fire scenarios are assumed to be of such size that an operable automatic fire sprinkler system would be activated (if present in the facility). Large fire scenarios are judged to be *anticipated* events without prevention. |
| SPILL | METAL CONTAINER: INTERNAL CORROSION Wastes with IDCs/WFCs exhibiting corrosive characteristics are stored in metal waste containers. Corrosives can react with metal containers from the inside, weakening the container walls and reducing the structural capacity of the container. When a weakened container is handled/moved it can catastrophically fail resulting in a container breach and subsequent release of a portion of the container contents. Container failure due to internal corrosion is judged to be an *unlikely* event without prevention. |
| SPILL | CONTAINER: DROP/FALL Waste containers are routinely raised above floor level (*e.g.*, during stacking, loading on transport vehicle, lifting into glovebox, etc.) using handling equipment including overhead bridge cranes, hoists, forklifts, and drum lifters. During container handling activities, various equipment failure mechanisms or improper rigging can result in waste container drops and falls. Upon impact with a hard surface (*e.g.*, floor, equipment, glovebox, other waste containers, etc.) waste containers can fail resulting in a container breach and subsequent release of a portion of the container contents. Container drop/fall scenarios are judged to be *anticipated* events without prevention. |
| SPILL | CONTAINER: PUNCTURE Waste containers are routinely moved using forklifts. A forklift operator error when attempting to position the tines can result in the forklift tines puncturing one or more waste containers. Upon container puncture, a portion of the container contents can be released. Container puncture scenarios during material handling are judged to be *anticipated* events without prevention. Compressed gas cylinders (*e.g.*, acetylene, propane, etc.) are routinely used during maintenance activities. If a cylinder valve were accidentally sheared off during cylinder handling, the cylinder can become an airborne missile that impacts |



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**Table 6-2** Storage and Handling (SH) Accident Scenarios

| Scenario Type | Description |
|---|---|
| | and punctures nearby waste container(s) resulting in a release of a portion of the container contents. Container puncture scenarios due to cylinder impacts are judged to be *unlikely* events without prevention. |
| SPILL | CONTAINER: IMPACT Waste containers may be physically impacted several ways during storage. Material handling equipment (*e.g.*, forklifts) can inadvertently impact waste containers resulting in crushing or toppling; raised or suspended loads can drop onto waste containers as a result of lifting equipment failure or improper rigging; exceedance of floor loadings can result in toppling; and falling overhead equipment or structure (due to degradation or a seismic event) can impact waste containers. Container impact scenarios involving handling equipment are judged to be *anticipated* events without prevention while impact scenarios due to exceedance of floor loadings, structural degradation, or seismic events are judged to be *unlikely* without prevention. |
| EXPLOSION | CONTAINER Flammable gas generation, principally hydrogen, in metal waste containers can lead to an internal explosion in a TRU waste container. The radioactive decay (radiolysis processes) of TRU waste material interacts with hydrogenous waste materials and produces hydrogen and oxygen gases. The gases can accumulate in the waste container to the point where a hydrogen explosion potential exists. Since little energy, that associated with a static charge can ignite flammable hydrogen/oxygen mixtures, static charges generated during container movements can ignite the hydrogen resulting in overpressurization/failure of the container and a radiological release. A container internal explosion scenario is considered an *unlikely* event without prevention. |
| SPILL/FIRE | CONTAINER SPILL/FIRE: EXTERNAL EVENT In the event that an aircraft crashes into a waste management facility, two release mechanisms are considered; spill and fire. This spill/fire scenario is a combination of two separate failure paths: (1) container failure/ external/mechanical/impact/NPH/EE and (2) container failure/external/thermal/fire/NPH/EE. The kinetic energy dissipated during aircraft impact into waste containers can breach several containers resulting in a spill of all or a portion of the container contents. Subsequent to impact, an ensuing pool fire can involve a number of waste containers. The pool fire can involve the waste containers spilled due to aircraft impact (unconfined material fire) as well as additional waste containers that may not have been breached due to aircraft impact (confined material fire). Aircraft spill/fire scenarios are judged to be *extremely unlikely* events without prevention. |

### 6.2.2 Waste Characterization – Chemical (CC) Accident Scenarios

*Reserved*

### 6.2.3 Waste Characterization – Radiological (CR) Accident Scenarios

*Reserved*

### 6.2.4 Repackaging and Treatment (RT) Accident Scenarios

The eight scenarios previously discussed in Table 6-2 are also applicable during RT activities because SH activities must be performed in direct support of RT activities. For example, waste receipt, handling, and staging (short-term storage) are required prior to and after

RT activities. In addition to the eight SH scenarios, two additional scenarios applicable to RT activities are listed and described in Table 6-3. Section 9, *Repackaging and Treatment (RT) Accident Analysis*, further evaluates these accident scenarios considering confinement enclosure type (*e.g.*, glovebox, contamination cell, Perma-Con, etc.), waste type (*e.g.*, LLW, TRU), MAR quantity, and damage ratio. Based on further evaluation of the accident scenario(s), the most representative scenarios associated with RT activities are analyzed to determine accident frequencies, consequences, and risk classes.

**Table 6-3** Repackaging and Treatment (RT) Accident Scenarios

| Scenario Type | Description |
|---|---|
| FIRE | CONFINEMENT ENCLOSURE. TRU and LLW repackaging and treatment activities will involve combustible waste materials that, if ignited, can result in a radiological release. Ignition of combustible materials can occur due to confinement enclosure electrical system failures, spontaneous combustion of pyrophoric or other materials, or incompatible chemicals. Confinement enclosure fires are judged to be *anticipated* events without prevention. |
| SPILL | IMPACT/PUNCTURE OF CONFINEMENT ENCLOSURE. TRU and LLW repackaging and treatment activities will generally be conducted inside some form of confinement enclosure (*e.g.*, glovebox, contamination cell, Perma-Con, baghouse, glove bag, etc.). In some cases LLW may be repackaged outside confinement (*e.g.*, radioactive material by default). Confinement enclosures can be damaged and breached from either inside or outside the structures. External damage can occur due to impact from material handling equipment (*e.g.*, forklift, drum lifter, etc.); puncture by a compressed gas cylinder sent airborne because the valve is accidentally sheared off; impact from overhead equipment or structure during a seismic event; or overpressure from an external explosion of a flammable gas/oxygen mixture. Internal damage can occur due to suspended loads/materials contacting the confinement structure walls or the dropping of suspended loads inside the structure. A confinement enclosure breach will result in a release of all or a portion of the material being processed inside the enclosure. External damage to confinement enclosures due to material handling equipment is judged to be *anticipated* without prevention. External damage caused by a compressed gas cylinder, a facility explosion, or a seismic event is judged to be *unlikely* without prevention. Internal damage to confinement enclosures is judged to be *anticipated* without prevention. |

### 6.2.5 Waste Generation (WG) Accident Scenarios

*Reserved*

### 6.2.6 Routine Activities (RA) Accident Scenarios

Routine activities do not directly involve radiological materials, their performance cannot in and of themselves result in a radiological release. However, the conduct of routine activities within or near waste storage or repackaging and treatment areas can result in scenarios not previously addressed. Two accident scenarios applicable to RA conducted in waste storage or repackaging areas are listed and described in Table 6-4. Section 13, *Routine Activities (RA) Accident Analysis*, further evaluates these accident scenarios considering container type, waste type, MAR quantities, and damage ratio. Based on further evaluation of the accident scenario(s),



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the most representative scenarios associated with RA are analyzed to determine accident frequencies, consequences, and risk classes.

**Table 6-4** Routine Activities (RA) Accident Scenarios

| Scenario Type | Description |
|---|---|
| FIRE | CONTAINER: DIRECT FLAME IMPINGEMENT Flammable gas torches (propane, oxyacetylene, etc.) are routinely used during facility maintenance and construction activities. In the event that a flammable gas device flame comes into direct contact with a stored waste container, a breach of the container is possible resulting in a radiological release. Direct flame impingement scenarios are judged to be *unlikely* events without prevention. |
| EXPLOSION | FACILITY Flammable gases such as acetylene and propane are routinely used during facility maintenance activities. In the event that a flammable gas is inadvertently or accidentally released into a waste storage area, a deflagration of an entire room or a localized deflagration of an air/gas mixture within the flammable range can occur. The adjacent "external explosion" can impact multiple waste containers resulting in a radiological release. Facility explosion scenarios are judged to be *unlikely* events without prevention. |

# 7. ACCIDENT ANALYSIS PROCESS

The accident analysis process examines each of the accident scenarios described in Section 6.2, *Accident Scenarios Requiring Further Analysis*. The analysis process performs multiple functions including: (1) determination of any potential analysis variations for each accident scenario (*e.g.*, a fire scenario can occur in an area supported by automatic fire suppression or in an area with no automatic fire suppression capability); (2) refinement of accident scenario progression; (3) refinement of accident scenario initial frequency bin assignment; (4) determination of accident scenario initial consequence bin assignment; (5) determination of accident scenario risk class; (6) identification of protective features that could be credited to reduce the risk class associated with representative accident scenarios; and (7) determination of the final prevented/mitigated accident scenario risk class.

As previously mentioned, the accident scenarios described in Section 6.2 may impact several types of radioactive material containers/confinement that are distinguished by the type of radioactive material, the quantity of radioactive material, and the resistance of the container/confinement to various accident scenarios. The various containers and confinement enclosures defined for the accident analysis process are: (1) Type B shipping containers; (2) POCs; (3) metal TRU waste containers, drums or boxes; (4) metal LLW containers, drums or boxes; (5) wooden LLW boxes/crates, (6) gloveboxes, (7) contamination cells, and (8) perma cons. Radioactive material contained as contamination in filter plenums, in ducting, in various components, and on structures has been determined to represent a Standard Industrial Hazard due to negligible contamination levels (see the Contamination Hazard discussion Section 5.3, *Radioactive Materials (Hazard/Energy Source 4)*) and is not included in this accident analysis process.

By considering various scenario type/container type combinations, representative accident scenarios are identified and analyzed to determine accident consequence and risk class. The accident analysis investigates the consequences associated with the accident scenario for three receptors: (1) the public, as represented by the MOI; (2) the CW; and (3) the IW. The MOI and CW consequence evaluations are quantitative while the IW consequence evaluation is strictly qualitative.

## 7.1 ACCIDENT SCENARIO DISCUSSIONS AND ACCIDENT SCENARIO SUMMARY TABLES

The purpose of the accident analysis process is to refine the assessment of the risk associated with waste management facility operations and to determine the appropriate set of protective features or controls to ensure safe operation. Risk assessment refinement can be accomplished by improving the understanding of accident scenario progression, by improving the quality of the estimate of the scenario frequency, and by improving the assessment of accident scenario dose consequences. Appropriate control set determination can be accomplished by initially crediting a set of protective features/controls that are expected to be in place during operation (*e.g.*, passive controls such as container integrity and container fissile material loading), by assessing the acceptability of the scenario risk under the expected set of controls, and by



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identifying appropriate controls for scenario risk reduction in cases where the scenario risk is unacceptable. Control appropriateness may be determined using multiple factors including: (1) risk reduction benefit; (2) control cost; (3) degree of unacceptable risk; and (4) control impact on operations.

Accident analyses presented in Sections 8 through 13 address the scenarios associated with a specific activity module. Each section begins with a general discussion of the scenarios to be evaluated and covers the determination of any required variations within the general scenario type (*e.g.*, fire, spill, explosion, etc.). The sections continue with representative accident scenario analyses.

For each representative accident scenario to be analyzed, an accident scenario discussion and corresponding summary table is provided. The scenario discussion and summary table present information describing: (1) the accident scenario sequence/progression; (2) the assumptions made in the analysis of the scenario; (3) the frequency bin assignment for the accident scenario, potentially under multiple sets of credited protective features; (4) MAR determination, (5) the dose consequence and/or consequence bin assignment for the scenario, potentially under multiple sets of credited protective features; (6) the corresponding scenario risk class for these situations; and (7) the sets of credited and defense-in-depth protective features associated with scenario prevention and mitigation. The format for the scenario discussion and scenario summary table is presented in the following text.

## 7.2 ACCIDENT SCENARIO DISCUSSION FORMAT

The accident scenario discussions for each scenario evaluated has a consistent format as described below.

- ***Accident Scenario* Section**: This section of the accident scenario discussion provides a description of the accident scenario being analyzed. This description addresses potential mechanisms for accident initiation, the relationship of waste management facility activity module to the scenario, accident scenario progression, and some general information on accident modeling assumptions.

- ***Accident Frequency* Section**: This section of the accident scenario discussion addresses the scenario frequency bin determination. Any protective features credited in the scenario frequency determination are identified.

- ***Material-At-Risk* Section**: This section of the accident scenario discussion addresses the scenario MAR. Assumptions dealing with damage ratios (DRs) and numbers of containers involved in the scenario are presented for each container and/or waste type impacted by the scenario. The basis for any DR values less than 100 % and any protective features credited in the MAR determination are identified.

- ***Accident Consequence* Section**: This section of the accident scenario discussion addresses the radiological dose consequences associated with the accident scenario. Based on the scenario progression, credited protective features, and the scenario



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MAR, consequences for the CW and the MOI are calculated. These analyses are performed using the methodology described in Section 4.2.1, *Radiological Risk*. In addition, a qualitative determination of IW consequences is presented along with the basis for the determination. Some discussion dealing with the consequences for workers within the facility but located away from the accident may be presented in cases where the evaluated IW consequences are determined to be high. The discussion also presents the accident scenario risk class for each receptor based on the scenario frequency bin and consequence bin assignments.

## 7.3 CONTROL SET VULNERABILITY SECTION

A control set vulnerability section follows the analysis of each general scenario type (*e.g.*, following the SH fire scenario section, the SH spill scenario section, etc.). This section of the accident scenario discussion addresses the vulnerability of the control set developed from the protective features credited for accident prevention and mitigation. The control set vulnerability discussions address the impact of credited protective features failure. The control set developed for each set of accident scenarios includes preventive and mitigative features that are credited in the determination of scenario frequency, consequence, and risk class. Only single failures of credited features are addressed. The credited protective features are carried forward into the *Waste Management Facilities Technical Safety Requirements* (Ref. **Error! Bookmark not defined.**).

Although the active credited preventive and mitigative features may be assured of high operational reliability by the TSRs and System Category (SC) designations, the active features are still vulnerable to failure. Therefore, qualitative evaluations of scenario frequencies and consequences are performed that include the failure of active hardware protective features and/or Administrative Controls in the accident scenario progression. This control set vulnerability assessment helps (1) confirm the adequacy of the control set; or (2) identify additional required controls to reduce the failed protective feature scenario risk class.

For credible cases in which the failed protective feature scenario risk class is higher than Risk Class III, preferentially, risk reduction is addressed by the identification of additional controls or, alternatively, risk acceptability is addressed by the discussion of available defense-in-depth controls. That is, when a high risk scenario results from consideration of credited protective feature failure, the analysis focuses on identifying appropriate protective features that can be credited to reduce the scenario risk class, particularly in the case where the high risk scenario is in the *unlikely* frequency bin. If appropriate protective features cannot be identified, the analysis assesses the adequacy of available defense-in-depth protective features as justification for acceptance of the scenario risk

## 7.4 ACCIDENT SCENARIO SUMMARY TABLE FORMAT

The accident scenario summary table for each evaluated scenario is presented at the end of the general accident scenario type section (*e.g.*, the summary tables for the analyzed SH fire scenarios are located at the end of the section dealing with fires). The tables have a consistent format as described below.

- ***Hazard*** **Field**: This field describes the hazard(s) being evaluated. References to the Hazard/Energy Source entries in Table 5-4 are made.
- ***Accident Type*** **Field**: This field defines the accident type being evaluated and the hazardous material form or container/confinement. A brief description of the scenario progression is provided along with the analyzed effective MAR. Additional information may also be included to indicate the size of the accident.
- ***Cause or Energy Source*** **Field**: This field lists the initiator or combination of initiators of the accident. References to the Hazard/Energy Source entries in Table 5-4 are made. Since the accidents being analyzed are representative scenarios, there could be multiple initiators causing the same basic accident (*e.g.*, *Vehicles, Material Handling Equipment; Raised or Suspended Loads/Materials*; *Stacked Waste Containers* could all be spill initiators).
- ***Applicable Activity(ies)*** **Field**: This field relates the accident scenario back to the waste management facility activity modules. Activity module acronyms, as defined in Table 1-3 are used (*e.g.*, SH, CC, CR, RT, WG, and RA). Activity module relationships to the analyzed scenarios are defined in Section 6.2 as part of the development of the accident scenarios.
- ***Receptor*** **Column**: This column lists the receptor for which the dose consequence results or consequence determinations displayed in the row are applicable. Three receptors are considered: the MOI (representing the public), the CW, and the IW. A separate row is needed for each of these receptors because they are evaluated separately. Consequences for the MOI and the CW are generally presented as quantitative radiological doses in rem along with the corresponding consequence bin determination, but consequences for the IW are only presented in the qualitative terms as a consequence bin assignment.
- ***Scenario Frequency - Without Prevention & With Prevention*** **Columns**: These columns present a conservative estimate of accident scenario frequency associated with the crediting of potentially varying sets of preventive features. Accident scenario frequencies are categorized into qualitative frequency bins as suggested by DOE-STD-3011-94 (Ref. 7) and discussed in Section 4.2, *Risk Classification Methodology*. The frequency bin assignment is based on qualitative judgments. The frequency section in the scenario discussion describes which inherent preventive features were specifically credited to arrive at the assigned frequency bin for the ***Without Prevention*** column entry. Inherent preventive features are included in the ***Protective Feature*** column of the accident scenario summary table and are highlighted as underlined text to distinguish the inherent protective features from credited

preventive features identified as part of the scenario risk reduction process, the results of which are displayed in the ***With Prevention*** column.

In assigning accident scenario frequencies for both the "without prevention" and the "with prevention" situations, the guidance presented below was generally used in the determination of the initial frequency bin assignment for representative scenarios and may be used in the determination of scenario frequencies as additional preventive features are credited in the analysis. The general guidance for scenario frequency bin determinations is as follows:

- Administrative Controls: In general, an Administrative Control may be used to reduce the scenario frequency by one order of magnitude (multiply by $10^{-1}$). Two or more independent Administrative Controls can be combined for a frequency reduction of no more than two orders of magnitude (multiply by $10^{-2}$) or one frequency bin. Exceptions will be noted and justified.
- SC 1/2 SSC in TSRs: In general, a SC 1/2 SSC that is well maintained and monitored due to its inclusion in the TSRs may be used to reduce the scenario frequency by two orders of magnitude (multiply by $10^{-2}$) or one frequency bin. Exceptions will be noted and justified.

***Scenario Consequence - Without Mitigation & With Mitigation*** **Columns**: These columns present a conservative estimate of accident scenario consequence associated with the crediting of potentially varying sets of mitigative features. Accident scenario consequences are categorized into qualitative consequence bins as suggested by DOE-STD-3011-94 (Ref. 7) and discussed in Section 4.2.1, *Radiological Risk*. The consequence bin assignment for the CW and MOI is based on a quantitative dose consequence value determined by conservatively estimating the radiological dose to the receptor that is then compared to the radiological dose consequence bin thresholds in Table 4-3. The consequence to the IW for the "*with mitigation*" scenario is determined qualitatively using the guidance in Table 4-3. The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** column is marked "*Not Applicable.*"

Non-criticality radiological dose consequences for the CW and the MOI are determined using the formulation presented in Section 4.2.1, *Radiological Risk*. For all accident scenarios not dealing with severe weather induced accidents (*e.g.*, high wind, tornado), a conservative atmospheric dispersion factor (*i.e.*, 95$^{th}$ percentile $\chi/Q$ value) is used in the calculation of CW and MOI radiological dose consequences for comparison to the dose thresholds in Table 4-3. The MAR section in the scenario discussion describes how the effective MAR was determined. The effective MAR is an input to the dose consequence calculation and can affect the consequence bin determination. The consequence section in the scenario discussion describes which inherent mitigative features, if any, were specifically credited to arrive at the assigned consequence bin for the ***Without Mitigation*** column entry. Inherent mitigative features are included in the ***Protective Feature*** column of the accident scenario summary table and are highlighted as underlined text to distinguish the inherent protective features from credited mitigative features identified as part of the scenario risk reduction process, the results of which are displayed in the ***With Prevention*** column.

- ***Scenario Risk Class - Without Prevention/Mitigation & With Prevention/ Mitigation* Columns**: These columns present a determination of accident scenario risk class associated with the crediting of potentially varying sets of protective features. The scenario risk class is determined by entering Table 4-1 with the scenario frequency and consequence bin assignments for a specific receptor, as discussed in Section 4.2, *Risk Classification Methodology*. If the scenario risk class displayed in the ***With Prevention/Mitigation*** column is Risk Class I or Risk Class II for either the IW, CW or the MOI, then the scenario will be considered a *Risk Dominant Accident Scenario* in individual facility AB documents. The individual facility AB documents will discuss application of additional controls that could reduce the scenario risk class. The "*without mitigation*" scenario is evaluated only when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Prevention/Mitigation*** column is marked "*Not Applicable.*"

- ***Protective Feature* Column**: This column presents the preventive and mitigative protective features credited in the evaluation of or providing defense-in-depth for each accident scenario. As noted in the ***Scenario Frequency*** and ***Scenario Consequence*** column discussions, protective features that are underlined were inherently credited in the initial frequency and consequence bin assignments for the scenario. Protective features that are not underlined may be part of an additional set of features that were credited in the final frequency and consequence bin assignments for the scenario. Alternatively, features that are not underlined may be a set of identified defense-in-depth protective features (see the entries in the ***Feature Type*** column for classification). The function performed by each of the protective features listed in the table is defined in the accident scenario discussion text.

  It should be noted that all accident scenarios inherently credit an integrated set of SMPs to provide an infrastructure for conduct of operations and for general implementation and maintenance of any specifically identified controls.

- ***Feature Type* Column**: This column identifies whether the protective feature listed in the ***Protective Feature*** column of the table is considered a credited feature (indicated by the letter, "C") or a feature that is not directly credited in the scenario frequency or consequence bin determinations but serves as a defense-in-depth feature (indicated by the letter, "D"). A credited protective feature can be directly tied to a reduction in accident scenario frequency or consequences, even though the reduction may not be sufficient to change a frequency or consequence bin assignment. A defense-in-depth protective feature cannot be related to the scenario frequency or consequence bin determinations but provides additional layers of defense for the protection of the



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public, CW, or IW. The defense-in-depth features are identified in the control set adequacy and vulnerability discussions.

- ***Feature Purpose* Column**: This column identifies whether the protective feature listed in the ***Protective Feature*** column of the table performs a preventive function that may be credited in scenario frequency reduction (indicated by the letter, "P"), performs a mitigative function that may be credited in scenario consequence reduction (indicated by the letter, "M"), or performs a combination of prevention and mitigative functions (indicated by the letters, "P/M"). An example of the latter situation is the fire suppression system that may prevent large fires while mitigating the consequence of the smaller, suppressed fire.
- ***Reference to TSRs* Column**: This column cross-references an identified protective feature to the corresponding Limiting Condition for Operation (LCO) or Administrative Operating Limit (AOL) in the *Waste Management Facility Technical Safety Requirements*.

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# 8. STORAGE AND HANDLING (SH) ACCIDENT ANALYSIS

This section presents the accident analysis for the fire, spill, and explosion accident scenarios associated with SH activities as identified in Table 6-2, *Storage and Handling (SH) Accident Scenarios*:

Fires:
- Facility Fire: 1 mega-watt (MW)
- Facility Fire: 4 MW

Spills:
- Container Spill: Internal Corrosion
- Container Spill: Drop/Fall
- Container Spill: Puncture
- Container Spill: Impact

Spill/Fire:
- Container Spill/Fire: External Event

Explosions:
- Container Explosion

## 8.1 FIRE SCENARIO ACCIDENT ANALYSIS

### 8.1.1 Fire Scenario Development and Selection

The analyzed fire scenarios include a small 1 MW fire and a larger 4 MW fire involving transient combustibles (*e.g.*, plywood, wooden pallets, etc.) ignited in close proximity to stored waste containers. Fire scenarios involving routine activities (*e.g.*, direct flame impingement during cutting/welding activities) are evaluated in Section 13, *Routine Activities (RA) Accident Analysis*. The MAR values associated with the container types evaluated in the fire scenarios are presented in Table 8-1.

**Table 8-1** Fire Scenario MAR Values

| CONTAINER TYPE | CONTAINER CONFIGURATION | MAXIMUM MAR (WG Pu equivalent) | EFFECTIVE MAR (WG Pu equivalent) |
|---|---|---|---|
| Metal LLW box | single | 3 grams | 3 grams |
| Metal LLW drum | single | 0.5 grams | 0.5 grams |
| Metal LLW drum[1] | pallet, 4 containers | 2 grams | 1.5 grams |
| TRUPACT II SWB or metal waste box | single | 320 grams | 320 grams |
| TRU drum | single | 200 grams | 200 grams |
| TRU drum[1] | pallet, 4 containers | 800 grams | 600 grams |

1. The involvement of 4 palletized waste drums in facility fire scenarios is assumed to be 3 drums. See Sections 8.1.1.1 and 8.1.1.2.



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Waste management facility storage areas include: (1) small rooms with relatively low ceilings; (2) large rooms with relatively high ceilings; and (3) outside storage areas. All of the TRU waste storage areas are inside facilities and are equipped with automatic sprinkler systems. Storage areas that have TRU waste exclusively packaged in Pipe Overpack Containers are not required to have a sprinkler system. Most of the LLW storage areas have no fire suppression systems. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text.

In order to determine representative fire scenarios to evaluate further, an assessment of the impact of a fire on various waste containers is necessary. POCs and Type B containers are designed in a manner that precludes failure of the containers during expected storage area fires (Ref. 34). POCs are vulnerable to long-duration fuel pool fires, but storage area fires are postulated as solid combustible material fires of short duration (10 minutes). Fires involving flammable/combustible liquids are not considered because a ***fuel/combustible loading and ignition source control*** program restricts the introduction of flammable/combustible liquids into waste storage areas. Attributes of the ***fuel/combustible loading and ignition source control*** program include (1) storing flammable/combustible liquids inside NFPA approved cabinets, (2) limiting the quantity of flammable/combustible liquids, and (3) prohibiting the use of fossil-fueled material handling vehicles in interior waste storage areas.

Storage area fires are capable of impacting the radioactive material inventories of LLW and TRU waste containers (*i.e.*, metal boxes and drums). The ***fuel/combustible loading and ignition source control*** program prohibits wooden waste crates from most waste storage areas. Fire scenarios involving wooden waste crates are not evaluated in this NSTR. Such scenarios will be added in a future revision if necessary. While metal waste containers are not combustible, combustible material contents may be affected by fires outside the container resulting in pyrolysis, failure of the metal container lid seal, and venting of pyrolytic gases containing radioactive material through the failed container seal. For high temperature and fast burning fires (*e.g.*, fuel pool fires), the rate of pyrolytic gas generation and pressure increase in the container may exceed the rate at which the container can vent, resulting in a loss of the container lid and ejection of some of the container contents. Because flammable/combustible liquids and other combustible materials with high heat release rates are controlled in waste management facilities by the ***fuel/combustible loading and ignition source control*** program, fires with heat release rates sufficient to cause container lid loss are not further evaluated.

Fire Hazard Analyses (FHAs) supporting waste management facilities indicate that the fuel loading and fire potential in waste storage areas are generally low. Most facilities use only metal pallets for storage of waste containers. When stacked, these pallets are separated from the drum lids below by plywood sheets. The plywood sheets are combustible but are difficult to ignite. Wooden pallets are present in several facilities. These pallets are used for operational purposes (*e.g.*, material movement) and unused wooden pallets are not typically stored inside waste storage areas. Additionally, any combustible materials present inside a waste storage area must have a five-foot separation from waste containers (an attribute of the ***fuel/combustible loading and ignition source control*** program).

In order to model representative fire scenarios, it is assumed that up to ten wooden pallets are inadvertently left in a waste storage area and that the pallets are within five feet of stored waste containers. Such a condition represents a failure of the ***fuel/combustible loading and ignition source control*** program and its specific attribute of maintaining a five-foot separation.

Fire Protection Engineering (FPE) has concluded that a stack of three wooden pallets has a heat release rate of approximately 1 MW, a stack of five wooden pallets has a heat release rate of approximately 2 MW, and a stack of 10 pallets has a heat release rate of approximately 4 MW. For waste management facilities, it is judged that a failure of the ***fuel/combustible loading and ignition source control*** program would most likely result in a 1 MW fire. However, depending on how much combustible loading occurs, larger 2 MW and 4 MW fires are credible.

The ability of an ***automatic sprinkler system*** to suppress a fire is dependent on the fire heat release rate, ceiling height, and actuation time of the sprinklers. Waste storage area ceiling heights range from about 10 feet up to approximately 40 feet. Table 8-2 presents the results from a simplified fire analysis (Ref. 35) showing the minimum heat release rate, for moderate rate fires, required to actuate a sprinkler system for various ceiling heights. This information is not intended to be exact, but is intended to be an approximation of minimum fire sizes to actuate sprinkler systems.

**Table 8-2** Minimum Heat Release Rates to Actuate Sprinklers for Various Ceiling Heights

| CEILING HEIGHT (feet) | TIME TO ACTUATION (seconds) | HEAT RELEASE RATE (BTU) | HEAT RELEASE RATE (kW) |
|---|---|---|---|
| 10 | 109 | 131 | 138 |
| 20 | 193 | 743 | 784 |
| 30 | 279 | 2,046 | 2,200 |
| 40 | 370 | 4,200 | 4,400 |

Based on the information in Table 8-2, a 1 MW or 2 MW fire will actuate sprinklers in areas with ceiling heights of 20 ft or less and neither fire will actuate sprinklers in areas with ceilings in excess of 30 ft. A 4 MW fire will actuate sprinklers in areas with ceiling heights up to 40 ft.

### 8.1.1.1 1 MW Fire

An area approach can be used to conservatively estimate the number of waste containers impacted by a 1 MW fire involving stacked wooden pallets placed up against metal waste containers. Wooden pallets are approximately 4 ft wide by 4 ft long and 4 inches high. A stack of three pallets is therefore approximately one foot high. Fifty-five gallon metal waste drums are approximately 2 feet in diameter and 3 feet in height. Metal waste boxes and SWBs are 4 feet in height. Assuming the flame height is twice the height of the combustible load (*e.g.*, approximately two feet), the 1 MW fire would have direct flame impingement on only the



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first tier of waste containers. If the sprinkler system fails to actuate, it is assumed that the fire would self extinguish within ten minutes and impact only 3 drums (the corner drum and two adjacent drums on the first tier) or 1 metal box/SWB. However, if the sprinklers actuate, the 1 MW scenario would likely impact less than 3 drums or 1 metal box/SWB. Table 8-3 presents a summary of the number of drums impacted by facility fires for both unmitigated and mitigated (*i.e., **automatic sprinkler system*** actuation) cases.

**Table 8-3** Number of Waste Containers Impacted for Various Situations

| ESTIMATED FIRE SIZE | MITIGATED BY SPRINKLERS | NUMBER OF DRUMS IMPACTED BY FIRE | NUMBER OF BOXES IMPACTED BY FIRE |
|---|---|---|---|
| 1 MW | sprinklers fail/not actuated | 3 | 1 |
| | sprinklers work | 3 | 1 |
| 4 MW | sprinklers fail/not actuated | 9 | 2 |
| | sprinklers work | 6 | 1 |

### 8.1.1.2 4 MW Fire

A stack of ten pallets, yielding a 4 MW fire, is also possible in waste storage areas. A stack of ten pallets is approximately 3.3 ft high. Assuming the flame height is twice the height of the combustible load (e.g., approximately 6.7 feet), the 4 MW fire would have direct flame impingement on the first three tiers of waste containers. If the sprinkler system fails to actuate, it is assumed that the fire would eventually self extinguish and impact 9 drums (the corner drums and two adjacent drums on each of the first three tiers) or 2 metal boxes/SWBs. However, assuming that the ***automatic sprinkler system*** actuates, the 4 MW fire would be mitigated and would impact 6 drums or 1 SWB. Table 8-3 presents a summary of the number of drums impacted by facility fires for both unmitigated and mitigated (*i.e., **automatic sprinkler system*** actuation) cases.

### 8.1.1.3 Representative Fire Scenarios

The representative fire scenarios evaluated for waste management facility SH activities are:

- Fire Scenario 1 – 1 MW Waste Container Fire
- Fire Scenario 2 – 4 MW Waste Container Fire



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### 8.1.2 Fire Scenario 1 – 1 MW Waste Container Fire

This accident scenario is discussed below and is summarized in Tables 8-4 and 8-5. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The radiological dose (RADIDOSE) calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

A 1 MW fire may occur as a result of the presence of flammable gases (*Hazard/Energy Source 5B*), hydraulic fluid (*Hazard/Energy Source 6B*) or other combustibles (*Hazard/Energy Source 13G*) being ignited during the conduct of hot work (*Hazard/Energy Source 5C*), by exposure to electrical system components (*Hazard/Energy Source 5E*), or by a facility lightning strike (*Hazard/Energy Source 13H*). The fire is assumed to initially involve combustible materials located in close proximity to stored waste containers. The combustible loading associated with the fire is modeled as three wooden pallets located within five feet of waste containers. Per Fire Protection Engineering (FPE), a stack of three wooden pallets has a heat release rate of approximately 1 MW. The fire causes heating of the waste containers, pyrolyzing of the container contents, and subsequent venting of container gases containing radioactive material through the failed container lid seals. A violent loss of the lid from overpressure of the container is not postulated to occur due to the relatively slow heating rate of a solid combustible material fire (versus a flammable liquid pool fire that can cause lid loss), and the relatively low heat flux and total heat energy associated with the limited amount of combustibles. This assumption is supported by a ***fuel/combustible loading and ignition source control*** program that restricts flammable/combustible liquids and other combustible materials with high heat release rates from waste management facilities, or strictly controls the use of any such combustible materials. It is assumed that the 1 MW fire does not actuate the ***automatic sprinkler system*** and that the fire self extinguishes without involving additional waste containers.

Based on the MAR values in Table 8-1, the bounding container types/configurations evaluated for the 1 MW fire scenario are Case A: one LLW box (1 box = 3 grams WG Pu versus 3 drums = 1.5 grams WG Pu) and Case B: three TRU waste drums (3 drums = 600 grams WG Pu versus 1 box/SWB = 320 grams WG Pu).

The 1 MW fire is modeled as a confined material release due to the assumption that the fire only fails the container lid seals and does not lead to container lid loss. This assumption is supported by a ***waste container integrity*** control. The fire may last for 30 minutes or more but is conservatively evaluated as a short duration fire (modeled as a 10 minute release). Due to the limited amount of heat energy associated with this fire, a ground-level (non-lofted) release of the radioactive material is conservatively assumed.

*Scenario Modeling Assumptions:* Cases A and B: fire; confined material; 10 minute duration; non-lofted plume.

Accident Frequency

The postulated accident scenario is considered an *unlikely* event due to the ***fuel/combustible loading and ignition source control*** program. Attributes of the ***fuel/combustible loading and ignition source control*** program include (1) combustible materials must have a five foot separation from stored waste containers; (2) restrictions on the introduction of flammable liquids or other high heat release rate combustibles into waste storage areas without appropriate controls; (3) restrictions on smoking in the facilities; and (4) requirements that hot work permits be developed for the conduct of any spark, heat, or flame producing work in the facilities.

*Scenario Modeling Assumptions: unlikely* event.

Material-At-Risk

It is assumed that there is one or more failures of the ***fuel/combustible loading and ignition source control*** program that includes the attribute to not place combustible materials within five feet of metal waste containers.

For Case A, one metal LLW box (3 grams WG Pu) is involved in the fire. For Case B: three 55-gallon drums containing TRU waste are involved in the fire. ***Waste container integrity*** is credited to preclude fire propagation between waste containers. No more than 3 grams and 200 grams (WG Pu equivalent) of radioactive material will be in a LLW box and TRU waste drum, respectively. This is imposed as a ***container fissile material loading*** limitation.

*Scenario Modeling Assumptions:*

Case A: 1 metal LLW box; aged WG Pu; 3 grams; Solubility Class W DCF, DR =1.

Case B: 3 TRU waste drums; aged WG Pu; 600 grams; Solubility Class W DCF; DR = 1.

Accident Consequence

Case A: The radiological dose consequences of a facility fire involving one LLW metal box are *low* to the MOI (4.8E-3 rem @ 1,200 m, 1.7-E3 rem @ 2,367 m), and *low* to the CW (0.23 rem). The resulting risk class for Case A is Risk Class III for both the MOI and CW (*unlikely* frequency, *low* consequences).

Case B: The radiological dose consequences of a facility fire involving three TRU waste drums are *moderate* to the MOI (0.96 rem @ 1,200 m, 0.34 rem @ 2,367 m) and *high* (47 rem) to the CW. The resulting risk class for Case B is Risk Class II for the MOI (*unlikely* frequency, *moderate* consequences) and Risk Class I for the CW (*unlikely* frequency, *high* consequences).

The IW located in the vicinity of the fire could be seriously burned as a result of facility fire scenarios (*e.g.*, by coming in close proximity during egress or while attempting to control the fire). The more likely mechanism for IW serious injury or death deals with exposure to smoke leading to asphyxiation or to noxious components of the smoke. There is the potential for the IW to inhale radioactive material being carried in the effluent from the fire, but the IW would have to



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remain in the vicinity of the fire or in the path of the effluent. It would be relatively easy for the IW to vacate the area with minimum dose impact if the IW is not incapacitated. The radiological dose consequences for the IW are qualitatively judged to be *low* due to: (1) the limited amount of radiological material that is released due to ***container fissile material loading*** limits; (2) the indicators of a fire (*e.g.*, smoke, flames) that inform the IW of the event; and (3) building ***emergency response*** that directs the IW to evacuate. The resulting risk class for the scenario is Risk Class III for the IW (*unlikely* frequency, *low* consequence).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 1: Case A
Small Fire (1 LLW Metal Waste Box)
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | Y | | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.50E-03

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.3E-01 | 4.8E-03 |
| One | 2.3E-04 | 4.8E-06 |
| Two | 4.7E-07 | 9.6E-09 |
| Three | 9.3E-10 | 1.9E-11 |
| Four | 1.9E-12 | 3.9E-14 |

**Fire Scenario 1 - Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 1: Case A
Small Fire (1 LLW Metal Waste Box)
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | Y | | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.50E-03

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.3E-01 | 1.7E-03 |
| One | 2.3E-04 | 1.7E-06 |
| Two | 4.7E-07 | 3.4E-09 |
| Three | 9.3E-10 | 6.9E-12 |
| Four | 1.9E-12 | 1.4E-14 |

**Fire Scenario 1 - Case A; Radiological Dose Consequences; 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 6.00E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:

Fire Scenario 1: Case B
Small Fire (3 TRU drums)
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 6.00E+02 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 3.00E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 4.7E+01 | 9.6E-01 |
| One | 4.7E-02 | 9.6E-04 |
| Two | 9.3E-05 | 1.9E-06 |
| Three | 1.9E-07 | 3.9E-09 |
| Four | 3.7E-10 | 7.7E-12 |

**Fire Scenario 1 - Case B; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 6.00E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:

Fire Scenario 1: Case B
Small Fire (3 TRU Drums)
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 6.00E+02 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 3.00E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 4.7E+01 | 3.4E-01 |
| One | 4.7E-02 | 3.4E-04 |
| Two | 9.3E-05 | 6.9E-07 |
| Three | 1.9E-07 | 1.4E-09 |
| Four | 3.7E-10 | 2.7E-12 |

**Fire Scenario 1 - Case B; Radiological Dose Consequences; 2,367 m**



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## Table 8-4 Fire Scenario 1, Case A - 1 MW Fire – 1 Metal LLW Box

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container), 5B (Thermal Energy/Flammable Gases), and 13G (Other Hazards/Combustibles) |
| Accident Type | Fire involving combustibles in close proximity to waste containers in internal waste storage areas: 1 LLW Metal Box<br>Effective MAR = 3 grams of aged WG Pu |
| Cause or Energy Source | [energy sources] 5C (Hot Work) and 5E (Electric Power System) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | Not Applicable | @ 1,200 m<br>Low<br>4.8E-3 rem<br>@ 2,367 m<br>Low<br>1.7E-3 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Fire Extinguishers<br>Training<br>Fire Phones/Fire Department Response | C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>P<br>P<br>M | AOL 1<br>AOL 1<br>AOL 8<br>AOL 8<br>AC 5.4<br>AC 5.6<br>AC 5.4 |
| CW | Anticipated | Unlikely | Not Applicable | Low<br>0.23 rem | Not Applicable | III | Same as MOI | | | |
| IW | Anticipated | Unlikely | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Emergency Response<br>Training<br>Fire Phones/Fire Department Response<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>M<br>P<br>M<br>M | AOL 1<br>AOL 1<br>AOL 8<br>AOL 8<br>AC 5.5<br>AC 5.6<br>AC 5.4<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 8-5 Fire Scenario 1, Case B - 1 MW Fire – 3 TRU Drums

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container), 5B (Thermal Energy/Flammable Gases), and 13G (Other Hazards/Combustibles) |
| Accident Type | Fire involving combustibles in close proximity to waste containers in internal waste storage areas: 3 TRU Waste Drums<br>Effective MAR = 600 grams of aged WG Pu |
| Cause or Energy Source | [energy sources] 5C (Hot Work) and 5E (Electric Power System) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | Not Applicable | @ 1,200 m<br>Moderate<br>0.96 rem<br>@ 2,367 m<br>Moderate<br>0.34 rem | Not Applicable | @ 1,200 m<br>II<br>@ 2,367 m<br>II | Container Integrity<br>Container Fissile Material Loading<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Fire Extinguishers<br>Training<br>Fire Phones/Fire Department Response | C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>P<br>P<br>M | AOL 1<br>AOL 4<br>AOL 8<br>AOL 8<br>AC 5.4<br>AC 5.6<br>AC 5.4 |
| CW | Unlikely | Unlikely | Not Applicable | Low<br>47 rem | Not Applicable | I | Same as MOI | | | |
| IW | Anticipated | Unlikely | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Emergency Response<br>Training<br>Fire Phones/Fire Department Response<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>M<br>P<br>M<br>M | AOL 1<br>AOL 4<br>AOL 8<br>AOL 8<br>AC 5.5<br>AC 5.6<br>AC 5.4<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

### 8.1.3 Fire Scenario 2 – 4 MW Waste Container Fire

This accident scenario is discussed below and is summarized in Tables 8-6 and 8-7. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

A 4 MW fire may occur as a result of the presence flammable gases (*Hazard/Energy Source 5B*) or other combustibles (*Hazard/Energy Source 13G*) being ignited during the conduct of hot work (*Hazard/Energy Source 5C*), by exposure to electrical system components (*Hazard/Energy Source 5E*), or by a facility lightning strike (*Hazard/Energy Source 13H*). The fire is assumed to initially involve combustible materials located in close proximity to stored waste containers. The combustible loading associated with the fire is modeled as ten stacked wooden pallets located within five feet of waste containers. Per FPE, a stack of ten wooden pallets has a heat release rate of approximately 4 MW. The fire causes heating of the waste containers, pyrolyzing of the container contents, and subsequent venting of container gases containing radioactive material through the failed container lid seals. A violent loss of the lid from overpressure of the container is not postulated to occur due to the relatively slow heating rate of a solid combustible material fire (versus a flammable liquid pool fire that can cause lid loss), and due to the relatively low heat flux and total heat energy associated with the limited amount of combustibles. This assumption is supported by the requirement of a ***fuel/combustible loading and ignition source control*** program that restricts flammable/combustible liquids and other combustible materials with high heat release rates from waste management facilities or strictly controls the use of any such combustible material in waste management facilities. It is assumed that the 4 MW fire actuates the ***automatic sprinkler system***, which mitigates the fire.

The bounding container types/configurations evaluated for the 4 MW fire scenario depends on whether the fire is mitigated (e.g., ***automatic sprinkler system*** actuated) or unmitigated (e.g., ***automatic sprinkler system*** not actuated).

Based on the MAR values in Table 8-1 and the number of containers impacted for various situations shown in Table 8-3, the LLW container configuration evaluated is for an unmitigated 4 MW fire involving two metal LLW boxes (2 boxes = 6 grams WG Pu versus 9 drums = 4.5 grams WG Pu). A mitigated fire involving metal LLW boxes is not evaluated because waste management facilities that store only LLW are generally not protected by an ***automatic sprinkler system***. The 4 MW fire scenario impacting metal LLW boxes is evaluated as Case A.

The bounding TRU waste container type/configuration evaluated for an unmitigated 4 MW fire scenario is nine drums (9 drums = 1,800 grams WG Pu versus 2 metal boxes/SWBs = 640 grams WG Pu). By crediting an ***automatic sprinkler system***, the mitigated scenario involves six drums (6 drums = 1,200 grams WG Pu versus 1 metal box/SWB = 320 grams WG Pu). The 4 MW fire scenario impacting TRU waste drums is evaluated as Case B.



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The 4 MW fire is modeled as a confined material release due to the assumption that the fire only fails the container lid seals and does not lead to container lid loss. The fire may last for 30 minutes or more but is conservatively evaluated as a short duration fire (modeled as a 10 minute release). Due to the limited amount of heat energy associated with this fire, a ground-level (non-lofted) release of the radioactive material is conservatively assumed.

*Scenario Modeling Assumptions:* Case A and Case B: fire; confined material; 10 minute duration; non-lofted plume.

Accident Frequency

The postulated accident scenario is considered an *unlikely* event due to the ***fuel/combustible loading and ignition source control*** program. Attributes of this program include (1) a requirement that transient combustibles must have a five-foot separation from stored waste containers; (2) restrictions on the introduction of flammable liquids or other high heat release rate combustibles into waste storage areas without appropriate controls; (3) a requirement that no wooden waste crates are present in the waste storage areas, and (4) a requirement that hot work permits be developed for the conduct of any spark, heat, or flame producing work in the facilities.

*Scenario Modeling Assumptions: unlikely* event.

Material-At-Risk

It is assumed that there is one or more failures of the ***fuel/combustible loading and ignition source control*** program that includes the attribute to not place combustible materials within five feet of metal waste containers.

The combustible loading associated with the fire is not restricted to wooden pallets but the pallets are used as a representative combustible load. Small quantities of flammable liquids (*e.g.*, paint cans) could also be a candidate for the initial fire but it is expected that other fires involving small quantities of flammable liquids would have less impact and lead to less container involvement. The metal waste container (an attribute of the ***container integrity*** administrative control) is credited to preclude fire propagation between waste containers

For Case A, two metal LLW boxes are involved in the fire. No more than 3 grams of WG Pu equivalent will be packaged in a LLW box crediting ***container fissile material loading*** limits. Therefore, the total MAR for this case is 6 grams WG Pu equivalent. It is conservatively assumed that the entire contents of the impacted metal waste boxes are involved in the accident scenario (*i.e.*, DR = 1).

For Case B, nine TRU waste drums are involved in the unmitigated fire and six drums are involved in the mitigated fire. No more than 200 grams of WG Pu equivalent will be packaged in a TRU waste drum crediting ***container fissile material loading*** limits. Therefore, the total effective MAR for the unmitigated Case B is 1,800 grams WG Pu equivalent and the total effective MAR for the mitigated Case B is 1,200 grams WG Pu equivalent. It is conservatively assumed that the entire contents of the impacted drums is involved in the accident scenario (*i.e.*, DR = 1).

*Scenario Modeling Assumptions:*

Case A: 2 metal LLW boxes; aged WG Pu; 6 grams; Solubility Class W DCF; DR = 1

Case B unmitigated: 9 drums; aged WG Pu; 1,800 grams; Solubility Class W DCF; DR = 1. Case B mitigated: 6 drums; aged WG Pu; 1,200 grams; Solubility Class W DCF; DR = 1.

Accident Consequence

Case A: The radiological dose consequences of the 4 MW facility fire involving 2 metal LLW boxes are *low* to the MOI (9.6E-3 rem @ 1,200 m, 3.4E-3 rem @ 2,367 m) and *low* (0.47 rem) to the CW. The resulting risk class for Case A is Risk Class III for both the MOI and CW (*unlikely* frequency, *low* consequences).

Case B: The radiological dose consequences of the unmitigated 4 MW facility fire (*e.g.*, ***automatic sprinkler system*** not actuated) involving nine 55-gallon TRU waste drums are *moderate* to the MOI (2.9 rem @ 1,200 m, 1.0 rem @ 2,367 m) and *high* (140 rem) to the CW. The resulting risk class for the unmitigated Case B is Risk Class I for the MOI (*anticipated* frequency, *moderate* consequences) and Risk Class I for the CW (*anticipated* frequency, *high* consequences).

The radiological dose consequences of the mitigated 4 MW facility fire (*e.g.*, ***automatic sprinkler system*** actuated) involving six 55-gallon TRU waste drums are *moderate* to the MOI (1.9 rem @ 1,200 m, 0.69 rem @ 2,367 m) and *high* (93 rem) to the CW. The resulting risk class for the mitigated Case B is Risk Class II for the MOI (*unlikely* frequency, *moderate* consequences) and Risk Class I for the CW (*unlikely* frequency, *high* consequences).

The IW located in the vicinity of the fire could be seriously burned as a result of facility fire scenarios (*e.g.*, by coming in close proximity during egress or while attempting to control the fire). The more likely mechanism for IW serious injury or death deals with exposure to smoke leading to asphyxiation or to noxious components of the smoke. There is the potential for the IW to inhale radioactive material being carried in the effluent from the fire, but the IW would have to remain in the vicinity of the fire or in the path of the effluent. It would be relatively easy for the IW to vacate the area with minimum dose impact if the IW is not incapacitated. The radiological dose consequences for the IW are qualitatively judged to be *low* due to: (1) the limited amount of radiological material that is released due to ***container fissile material loading*** limits; (2) the indicators of a fire (*e.g.*, smoke, flames, actuation of the fire sprinklers, etc.) that inform the IW of the event; and (3) building ***emergency response*** that directs the IW to evacuate. The resulting risk class for the mitigated scenario is Risk Class III for the IW (*unlikely* frequency, *low* consequence). The resulting risk class for the mitigated scenario is Risk Class III for the IW (*unlikely* frequency, *moderate* consequence).



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 6.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Fire Scenario 2: Case A
4 MW Fire (2 Metal LLW Boxes)
MOI Distance = 1,200 m
UNMITIGATED (e.g., sprinklers not activated)

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | Y | | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 6.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.00E-03

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-01 | 9.6E-03 |
| One | 4.7E-04 | 9.6E-06 |
| Two | 9.3E-07 | 1.9E-08 |
| Three | 1.9E-09 | 3.9E-11 |
| Four | 3.7E-12 | 7.7E-14 |

**Fire Scenario 2 - Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 6.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Fire Scenario 2: Case A
4 MW Fire (2 Metal LLW Boxes)
MOI Distance = 2,367 m
UNMITIGATED (e.g., sprinklers not activated)

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | Y | | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 6.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.00E-03

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-01 | 3.4E-03 |
| One | 4.7E-04 | 3.4E-06 |
| Two | 9.3E-07 | 6.9E-09 |
| Three | 1.9E-09 | 1.4E-11 |
| Four | 3.7E-12 | 2.7E-14 |

**Fire Scenario 2 - Case A; Radiological Dose Consequences; 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.20E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 2: Case B
4 MW Fire (6 TRU Drums)
MOI Distance = 1,200 m
MITIGATED (e.g., sprinklers activated)

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | Y | | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 1.20E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 6.00E-01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 9.3E+01 | 1.9E+00 |
| One | 9.3E-02 | 1.9E-03 |
| Two | 1.9E-04 | 3.9E-06 |
| Three | 3.7E-07 | 7.7E-09 |
| Four | 7.5E-10 | 1.5E-11 |

**Fire Scenario 2 - Case B; Radiological Dose Consequences; 1,200 m (Mitigated)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.20E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 2: Case B
4 MW Fire (6 TRU Drums)
MOI Distance = 2,367 m
MITIGATED (e.g., sprinklers activated)

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | Y | | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 1.20E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 6.00E-01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 9.3E+01 | 6.9E-01 |
| One | 9.3E-02 | 6.9E-04 |
| Two | 1.9E-04 | 1.4E-06 |
| Three | 3.7E-07 | 2.7E-09 |
| Four | 7.5E-10 | 5.5E-12 |

**Fire Scenario 2 - Case B; Radiological Dose Consequences; 2,367 m (Mitigated)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.80E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 2: Case B
4 MW Fire (9 TRU Drums)
MOI Distance = 1,200 m
UNMITIGATED (e.g., sprinklers not activated)

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 1.80E+03 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 1.4E+02 | 2.9E+00 |
| One | 1.4E-01 | 2.9E-03 |
| Two | 2.8E-04 | 5.8E-06 |
| Three | 5.6E-07 | 1.2E-08 |
| Four | 1.1E-09 | 2.3E-11 |

Respirable Initial Source Term (g) = 9.00E-01

**Fire Scenario 2 - Case B; Radiological Dose Consequences; 1,200 m (Unmitigated)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.80E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 2: Case B
4 MW Fire (9 TRU Drums)
MOI Distance = 2,367 m
UNMITIGATED (e.g., sprinklers not activated)

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 5.0E-04 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 1.80E+03 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 1.4E+02 | 1.0E+00 |
| One | 1.4E-01 | 1.0E-03 |
| Two | 2.8E-04 | 2.1E-06 |
| Three | 5.6E-07 | 4.1E-09 |
| Four | 1.1E-09 | 8.2E-12 |

Respirable Initial Source Term (g) = 9.00E-01

**Fire Scenario 2 - Case B; Radiological Dose Consequences; 2,367 m (Unmitigated)**

**Table 8-6** Fire Scenario 2, Case A - 4 MW Fire – 2 LLW Metal Boxes/SWBs

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container), 5B (Thermal Energy/Flammable Gases), and 13G (Other Hazards/Combustibles) |
| Accident Type | Fire involving combustibles in close proximity to waste containers in internal waste storage areas: 2 LLW Boxes<br>Effective MAR = 6 grams of aged WG Pu |
| Cause or Energy Source | [energy sources] 5C (Hot Work) and 5E (Electric Power System) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | Not Applicable | @ 1,200 m<br>Low<br>9.6E-3 rem<br>@ 2,367 m<br>Low<br>3.4E-3 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Fire Extinguishers<br>Training<br>Fire Phones/Fire Department Response | C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>P<br>P<br>M | AOL 1<br>AOL 4<br>AOL 8<br>AOL 8<br>AC 5.4<br>AC 5.6<br>AC 5.4 |
| CW | Anticipated | Unlikely | Not Applicable | Low<br>0.47 rem | Not Applicable | III | Same as MOI | | | |
| IW | Anticipated | Unlikely | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Emergency Response<br>Training<br>Fire Phones/Fire Department Response<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>M<br>P<br>M<br>M | AOL 1<br>AOL 4<br>AOL 8<br>AOL 8<br>AC 5.5<br>AC 5.6<br>AC 5.4<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 8-7 Fire Scenario 2, Case B - 4 MW Fire – 9 TRU Waste Drums

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container), 5B (Thermal Energy/Flammable Gases), and 13G (Other Hazards/Combustibles) |
| **Accident Type** | Fire involving combustibles in close proximity to waste containers in internal waste storage areas: Mitigated: 6 TRU Drums; Unmitigated: 9 TRU Drums<br>Mitigated: Effective MAR = 1,200 grams of aged WG Pu; Unmitigated: Effective MAR = 1,800 grams of aged WG Pu |
| **Cause or Energy Source** | [energy sources] 5C (Hot Work) and 5E (Electric Power System) |
| **Applicable Activity(ies)** | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | @1,200 m<br>Moderate 2.9 rem<br>@ 2,367 m<br>Moderate 1.0 rem | @ 1,200 m<br>Moderate 1.9 rem<br>@ 2,367 m<br>Moderate 0.69 rem | @ 1,200 m<br>I<br>@ 2,367 m<br>I | @ 1,200 m<br>II<br>@ 2,367 m<br>II | <u>Container Integrity</u><br><u>Container Fissile Material Loading</u><br>Automatic Sprinkler System<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Fire Extinguishers<br>Training<br>Flow Alarm/Fire Department Response<br>Fire Phones/Fire Department Response | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D<br>D | M<br>M<br>M<br>P/M<br>P<br>P<br>P<br>M<br>M | AOL 1<br>AOL 4<br>LCO 3.1<br>AOL 8<br>AOL 8<br>AC 5.4<br>AC 5.6<br>AC 5.4<br>AC 5.4 |
| CW | Anticipated | Unlikely | High 140 rem | High 93 rem | I | I | Same as MOI | | | |
| IW | Anticipated | Unlikely | Moderate | Low | I | III | <u>Container Integrity</u><br><u>Container Fissile Material Loading</u><br>Fuel/Combustible Loading<br>Ignition Source Control<br>Emergency Response<br>Training<br>Fire Phones/Local Fire Alarm<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>P/M<br>P<br>M<br>P<br>M<br>M | AOL 1<br>AOL 4<br>AOL 8<br>AOL 8<br>AC 5.5<br>AC 5.6<br>AC 5.4<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

### 8.1.4 Control Set Vulnerability

Two preventive features have been credited in the determination of the scenario frequency and five mitigative features have been credited in the scenario consequence determination.

The credited preventive features are:

1. the separation attribute of the ***fuel/combustible loading and ignition source control*** program [five-foot separation between combustibles and waste containers and ensuring that combustible material quantities remain low] (all receptors); and
2. the ignition source control attribute of the ***fuel/combustible loading and ignition source control*** administrative control [restrictions on smoking in the facility, hot work permits, etc.] (all receptors).

The credited mitigative features are:

1. the ***container fissile material loading*** administrative control (all receptors);
2. the hardware control for an ***automatic sprinkler system*** (Fire Scenario 2, all receptors);
3. the ***container integrity*** administrative control (all receptors);
4. the ***fuel/combustible loading and ignition source control*** [flammable liquid or high heat release rate material restrictions] (MOI and CW); and
5. the ***emergency response*** administrative control (IW only).

Failure of the ***fuel/combustible loading and ignition source control*** preventive feature could increase the likelihood (to *anticipated*) that a fire could be ignited and sustained. The likelihood of a fire starting in a waste storage area is considered *unlikely* if these controls are implemented. Credited controls include (1) a requirement that transient combustibles must have a five-foot separation from stored waste containers; (2) restrictions on the introduction of flammable/combustible liquids or other high heat release rate combustibles into waste storage areas without appropriate controls; (3) a requirement that no wooden crates are present in the waste storage areas; and (4) a requirement that hot work permits be developed for the conduct of any spark, heat, or flame producing work in the facility.

Failure of the ***container fissile material loading*** mitigative feature (*e.g.*, underestimation of container radiological inventory, over batching, etc.) would result in additional MAR and a corresponding increase in the radiological dose consequences to all receptors.

Failure of the ***automatic sprinkler system*** mitigative feature would result in additional MAR involvement and a corresponding increase in the radiological dose consequences to the MOI and CW. The 4 MW fire is assumed to actuate the ***automatic sprinkler system***. Failure of the ***automatic sprinkler system*** to actuate is assumed to result in a larger fire that impacts nine 55-gallon waste drums or two metal waste boxes/SWBs before self extinguishing.

Failure of the ***container integrity*** mitigative feature (potential lid loss) or fire propagation between containers would result in a higher airborne release fraction. Credit is taken for this mitigative feature to preclude fire propagation between waste containers, thus reducing the amount of MAR involved.

Failure of the ***fuel/combustible loading and ignition source control*** mitigative feature dealing with the introduction of high heat rate combustibles can result in a higher heat release rate fire and potential container lid loss. Upon lid loss, container contents can become involved in the fire scenario as unconfined combustible material. The airborne release fraction for unconfined material is two orders of magnitude higher than for confined material.

Failures of the ***emergency response*** mitigative feature (i.e., inadequate emergency plan) can result in additional IW exposure to airborne radioactive materials.

In all situations discussed above, the following defense-in-depth features tend to mitigate or prevent the scenario but are not credited in the analysis:

- ***Fire Phones/Local Fire Alarm*** (IW only): ***Fire phone*** use activates ***local fire alarms*** and can reduce IW consequences by providing indication of a fire to facility personnel. Facility management may be informed by various alarms or personnel may be aware of the fire and use the ***fire phone***.

- ***Flow Alarm/Fire Department Response*** (MOI and CW only): For fires in areas covered by the ***automatic sprinkler system, flow alarm*** transmittal to the Fire Dispatch Center can lead to scenario mitigation due to ***Fire Department response***.

- ***Fire Phones/Fire Department Response*** (MOI and CW only): ***Fire phone*** communication to the Fire Dispatch Center can lead to scenario mitigation due to ***Fire Department response***.

- ***Fire Extinguishers*** are located throughout waste storage areas and are well maintained as required by the Fire Protection Safety Management Program . Use of fire extinguishers by facility personnel could mitigate the scenario by extinguishing the fire before container material release occurs. Although personnel do not receive hands-on portable fire extinguisher training, general training concerning fire extinguisher use is provided during the General Employee Training.

- ***Training*** (all receptors): The operator ***training*** program is an additional preventive feature that can potentially reduce the likelihood of incorrect introduction or placement of combustibles.

- ***Training*** (IW only): The IW ***training*** program is an additional mitigative feature that can reduce IW consequences as a reinforcement of the ***emergency response*** evacuation guidance.

- ***LS/DW*** (IW only): Facility management or other personnel can utilize the ***LS/DW system*** to reduce IW consequences by announcing the fire to facility personnel.

### 8.1.5 Fire Scenario Assumptions

In the evaluation of facility fire scenarios, assumptions are identified for prevention and/or mitigation of the accidents. Table 8-8 presents a listing of the assumptions specified in the evaluation of fire scenarios. The scenarios to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 8-8** Fire Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| LLW containers contain no more than 0.5 grams WG Pu equivalent in drums and 3 grams WG Pu equivalent in metal boxes. | Fire Scenario 1<br>Fire Scenario 2 | Sets the potential MAR for scenarios impacting LLW containers<br>***Container Fissile Material Loading*** |
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs. | Fire Scenario 1<br>Fire Scenario 2 | Sets the potential MAR for scenarios impacting TRU waste containers<br>***Container Fissile Material Loading*** |
| Type B shipping containers cannot be breached by any external fires expected during storage and handling operations. | Fire Scenario 1<br>Fire Scenario 2 | Reduces the likelihood of Type B shipping container failure from scenarios dealing with facility fires, other than direct flame impingement torch fires, to *Beyond Extremely Unlikely.*<br>***Container Integrity (Type B Shipping Container)*** |
| POCs cannot be breached by any external fires expected during storage and handling operations. | Fire Scenario 1<br>Fire Scenario 2 | Reduces the likelihood of POC failure from scenarios dealing with facility fires, other than direct flame impingement torch fires, to *Beyond Extremely Unlikely.*<br>***Container Integrity (Pipe Overpack Container)*** |
| Fire extinguishers are available and maintained to allow personnel fire suppression actions. | Fire Scenario 1<br>Fire Scenario 2 | Reduces the consequences of fire growth<br>***Fire Extinguishers*** |
| Automatic sprinkler systems are located in all TRU waste storage areas. | Fire Scenario 2 - Case B Only | Reduces the consequences of fire growth from the 4 MW fire.<br>***Automatic Sprinkler System*** |
| Metal waste container lids cannot be removed from the containers due to internal overpressurize from exposure to expected fires. | Fire Scenario 1<br>Fire Scenario 2 | Reduces the likelihood of metal waste container fire-induced lid loss associated with expected fires to *Beyond Extremely Unlikely.*<br>***Container Integrity*** |



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**Table 8-8** Fire Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| Metal waste container fires cannot propagate from container to container by exposure to expected fires. | Fire Scenario 1<br>Fire Scenario 2 | Reduces the likelihood of container-to-container fire propagation associated with expected fires to *Beyond Extremely Unlikely*.<br>***Container Integrity*** |
| A combustible material and ignition source control program shall be implemented to make fires in areas containing staged or stored radioactive material *unlikely* events.<br>Attributes of combustible material control include:<br>• high heat release rate combustible material restrictions;<br>• no wooden crates in internal waste storage areas;<br>• combustibles have five-foot separation from waste containers<br>Attributes of ignition source control include:<br>• restrictions on smoking in facilities;<br>• hot work permits | Fire Scenario 1<br>Fire Scenario 2 | Reduces the likelihood of facility fires potentially impacting radioactive material to *Unlikely*.<br>***Fuel/Combustible Loading and Ignition Source Control*** |
| Waste Management Facilities will develop facility-specific Emergency Plans. | Fire Scenario 1<br>Fire Scenario 2 | Reduces the exposure of the IW to releases.<br>***Emergency Response*** |



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## 8.2 SPILL SCENARIOS

### 8.2.1 Spill Scenario Development and Selection

The analyzed spill scenarios include a spill from a metal container due to internal corrosion, a spill of waste container(s) due to drops/falls, a spill of waste container(s) resulting from impact with material handling equipment, and a spill of waste container(s) resulting from impact from a compressed gas cylinder. Spills initiated by natural phenomena hazards and external events are evaluated in Sections 8.4 and 8.5, respectively.

The MAR values associated with the container types evaluated in the spill scenarios are presented in Table 8-9. The effective MAR for scenarios involving banded drums is less than for the same scenarios involving drums that are not banded. It is assumed that a banded pallet of drums falls in such a manner that one drum on the pallet is the first to impact the concrete floor and the other three drums impact the first drum causing it to breach. The first drum absorbs some of the force of three drums impacting it and the three drums are not postulated to breach. If the pallet of drums are not banded, it is assumed that each of the four drums can individually impact the floor and breach.

**Table 8-9** Spill Scenario MAR Values

| CONTAINER TYPE | CONTAINER CONFIGURATION | MAXIMUM MAR (WG Pu equivalent) | EFFECTIVE MAR (WG Pu equivalent) |
|---|---|---|---|
| Metal LLW box | single | 3 grams | 3 grams |
| Metal LLW drum | single | 0.5 grams | 0.5 grams |
| Metal LLW drum | pallet, 4 containers, banded | 2 grams | 0.5 grams |
| Metal LLW drum | pallet, 4 containers, not banded | 2 grams | 2 grams |
| TRUPACT II SWB or metal waste box | single | 320 grams | 320 grams |
| TRU drum | single | 200 grams | 200 grams |
| TRU drum | pallet, 4 containers, banded | 800 grams | 200 grams |
| TRU drum | pallet, 4 containers, not banded | 800 grams | 800 grams |

#### 8.2.1.1 Container: Internal Corrosion

This scenario is initiated by corrosive materials in the waste containers (*Hazard/Energy Source 13B*). Corrosives can weaken the container walls and reduce the structural capacity of the container. When a weakened container is handled/moved (*Hazard/Energy Source 11A*), it could breach and release of a portion of the container contents. This is an *unlikely* event that potentially involves the entire contents of a single waste container. The simultaneous failure of multiple containers due to corrosion *beyond extremely unlikely* and is not evaluated further. The single container scenario is not evaluated further because when it is compared to the drop/fall scenario, the frequency is less likely (*unlikely* versus *anticipated)* and the potential MAR is the same. Therefore, this spill scenario is not evaluated further.

**8.2.1.2** Container: Drop/Fall

To evaluate a bounding container drop/fall scenario the various waste container configurations (*e.g.*, single container or pallet of containers) and waste container types (*e.g.*, 55-gallon drum, TRUPACT II SWB, metal waste box) must be examined.

Spills from waste containers can be caused by drops/falls from forklifts during waste movement (*Hazard/Energy Source 8A*), drops/falls from upper tiers of stacks (*Hazard/Energy Source 8B*) due to stack impacts, and from vehicle impacts during movement or storage (*Hazard/Energy Source 7A*). It is assumed that drops or falls of distances greater than four feet are necessary to cause damage to the container whereby a release of radioactive material is possible. Waste containers stored in waste management facilities meet on-site transportation requirements [*i.e.*, at a minimum, the containers meet Type A specifications (qualified for a 4 foot drop) or are considered equivalent to Type A containers]. Fifty-five-gallon waste drums that topple or fall from the third or fourth tiers are susceptible to breach resulting in a radioactive release. Waste boxes may be stacked up to four high. The waste boxes are approximately four feet high; therefore boxes are susceptible to drops/falls that could result in a radioactive release if they are stacked on or above the second tier.

It is conservatively assumed that 100% of the contents of a waste container is released as a result of a drop/fall of greater than 4 feet. This is considered conservative because: (1) it is *unlikely* that the container lid will completely separate during impact of the waste container with a hard surface; and (2) it is *unlikely* that all internal packaging will breach, releasing all of the radioactive material. In a drop/fall of a pallet of banded drums, it is assumed that only one of the four drums is breached, releasing its entire contents. In the banded configuration, it is assumed that one drum takes the brunt of the impact with the hard surface with the weight of the other drums contributing to the impact forces on the drum.

Table 8-9 shows the estimated effective MAR for the different container configurations that may be involved in a drop/fall. These MAR values are used to determine which drop/fall scenario to evaluate further in Section 8.2.2 as a representative bounding spill scenario for SH activities.

**8.2.1.3** Container: Puncture

A radioactive material (*Hazard/Energy Source 4A, Hazard/Energy Source 4B*, or *Hazard/Energy Source 4C*) spill is postulated to occur as a result of puncturing a LLW or TRU waste container. Waste containers may be punctured by vehicle handling equipment (*Hazard/Energy Source 7A*) or by compressed gas bottles (*Hazard/Energy Source 6C*) that become airborne missiles. The puncture of the container may occur as a result of the container being impacted and punctured by material handling equipment while loading, unloading, and/or transferring the container from its receipt/shipment area to its storage/staging area. The puncture may occur in storage/staging areas as well as dock areas during receipt/shipment operations. Compressed gas cylinders (*e.g.*, nitrogen, acetylene, propane, etc.) are routinely used during maintenance activities. If a cylinder valve were accidentally sheared off during cylinder handling (changeout), the cylinder would become an airborne missile that could potentially impact and puncture nearby waste container(s) resulting in a release of a portion of the container contents.

Without controls, container puncture scenarios involving handling equipment are judged to be *anticipated* events while container puncture scenarios involving compressed gas cylinder missiles are judged to be *unlikely*. The puncture of a POC or Type B shipping container from either energy source is not considered a credible accident scenario because of the robust nature of these containers (Ref. 33, Section 4.5.1, *Accident Scenario Discussions and Accident Scenario Summary Table*).

Forklift operator error can result in a puncture, by the forklift tines, of either one metal box/SWB (LLW or TRU waste) or two adjacent drums (LLW or TRU waste) located on a pallet. A compressed gas cylinder missile can result in a puncture of up to three drums (LLW or TRU waste) or one metal box/SWB (LLW or TRU waste). Table 8-9 shows the estimated effective MAR for the container types that may be punctured. These MAR values were used to determine representative puncture scenarios for SH activities.

**8.2.1.4** Container: Impact

Waste containers may be physically impacted several ways during storage. Material handling equipment (*Hazard/Energy Source 7A*) can inadvertently impact waste containers resulting in crushing or toppling; raised or suspended loads (*Hazard/Energy Source 8A*) can drop onto waste containers in the event of lifting equipment failure or improper rigging; exceedance of floor loadings (*Hazard/Energy Source 13F*) can result in toppling; and falling overhead equipment or structure (*Hazard/Energy Source 13D and 13H*) can impact waste containers.

Impact scenarios resulting from exceeding floor loading limits or from structure degradation are considered *unlikely* events. These scenarios can result in container impacts and/or container toppling similar to the effects of a seismic event, which is also *unlikely*. The seismic event can potentially affect the entire inventory, whereas exceedance of floor loading limits or structure degradation would be localized and only affect the drums stored on that portion of the floor that fails or under the failed structure. The effective MAR would be greater during a seismic event and therefore, the consequences will bound the accident consequences resulting from exceeding floor loading limits or from structure degradation. The seismic event caused spill is further evaluated in Section 8.4.

Container impact scenarios involving handling equipment or raised/suspended loads are judged to be *anticipated* events and are bounded by the drop/fall spill scenario discussed in Section 8.3.1.2. These impact events are assumed to release no more radiological material than the drop/fall spill scenario and the *anticipated* accident frequency associated with material handling equipment impact or dropping a load is the same. Therefore, these impact spill scenarios are not evaluated further.

**8.2.1.5** Representative Spill Scenarios

The representative spill scenarios evaluated for waste management facility SH activities are:

- Spill Scenario 1 – Waste Container Drop/Fall
- Spill Scenario 2 – Waste Container Puncture by Forklift Tine
- Spill Scenario 3 – Waste Container Puncture by Compressed Gas Cylinder Missile

### 8.2.2 Spill Scenario 1 – Waste Container Drop/Fall

This accident scenario is discussed below and is summarized in Tables 8-10 and 8-11. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

A spill is postulated to occur as a result of breaching either one metal box/SWB or up to four 55-gallon waste drums containing radioactive material (*Hazard/Energy Source 4B*). The breach of the containers may occur as a result of the drums being raised by a forklift (*Hazard/Energy Source 8A*) and falling from that position, or as a result of being stacked (*Hazard/Energy Source 8B*) and then being impacted by material handling equipment (*Hazard/Energy Source 7A*) during facility operations. Upon impact with a hard surface, the containers are damaged (*e.g.*, crushed, split open, etc.) and the internal waste packages are breached by the force of the impact. This is considered a confined material release since the container and internal packaging (*e.g.*, rigid liner, polyethylene bag, etc.) will contain the material and prevent it from being released to the atmosphere.

Two cases are evaluated for this scenario. Case A involves the contents of one metal LLW box. The box is assumed to breach due to the impact with the concrete floor. This scenario bounds other mechanisms for LLW container breach due to the *anticipated* frequency of the scenario and the effective MAR involved in the scenario (four 55-gallon drums containing 0.5 grams each = 2 grams versus 3 grams in one box).

Case B involves the contents of four 55-gallon TRU waste drums or one metal TRU waste box/SWB. Four 55-gallon drums on a pallet that is being stacked on the third or fourth tier fall and impact the concrete floor resulting in container damage. Without crediting ***container stacking (banding)*** requirements, all four drums are assumed to breach. The DR is assumed to be 100% and results in an effective MAR of 800 grams WG Pu equivalent (4 drums × 200 grams/drum × 1.0). By crediting ***container stacking (banding)*** requirements, which require drums that are going to be stacked on the third and fourth tier to be banded, only one drum is postulated to breach (DR = 0.25), and the effective MAR is reduced to 200 grams WG Pu equivalent (4 drums × 200 grams/drum × 0.25). It is assumed that the pallet of drums falls in such a manner that one drum on the pallet is the first to impact the concrete floor and the other three drums impact the first drum causing it to breach. Since it is postulated that only one TRU waste drum will breach when crediting ***container stacking (banding)***, a drop/fall of a TRU waste box/SWB containing 320 grams WG Pu equivalent becomes the bounding drop/fall scenario. Both scenarios are considered *anticipated* events.

*Scenario Modeling Assumptions:* Case A and Case B: spill; confined material; 10 minute duration.

Accident Frequency

The scenario frequency is *anticipated* because material handling accidents have occurred at the Site in the past. This is judged to be a conservative frequency determination based on interpretation of Site data, which indicates that the majority of past events have been of relatively low energy, typically resulting in the denting or dropping of containers with no loss of containment. Waste containers brought into waste management facilities must meet on-site transportation requirements, therefore, actual breaches of containers due to drops or falls are probably less likely than *anticipated* due to the strength of the waste containers. With controls, the accident frequency conservatively remains *anticipated.*

*Scenario Modeling Assumptions: anticipated* event

Material-At-Risk

Case A: The evaluated MAR is 3 grams of WG Pu equivalent. ***Container fissile material loading*** for the waste management facilities allows up to 3 grams WG Pu equivalent to be contained in each LLW box. Metal waste boxes meeting ***container integrity*** requirements (*i.e.*, on-site transportation requirements) are assumed to withstand a drop/fall from four feet or less without breaching. Therefore, a fall from a second, third or fourth tier is assumed to result in a container breach (the boxes are 4 feet high). A Solubility Class W dose conversion factor is used in modeling this scenario.

Case B: The evaluated MAR is 320 grams of WG Pu equivalent. ***Container fissile material loading*** for waste management facilities allows up to 320 grams WG Pu equivalent to be contained in each TRU waste box/SWB. Drums meeting ***container integrity*** requirements (*i.e.*, on-site transportation requirements) are assumed to withstand a drop/fall from four feet or less without breaching. Therefore, boxes/SWBs stacked on the second, third or fourth tiers are susceptible to breaching if they are subject to a drop or fall.

This scenario assumes that the box/SWB drops or falls in a manner that results in the release of the entire contents of the container. A Solubility Class W DCF is used in modeling both cases of this scenario.

*Scenario Modeling Assumptions:*

Case A: 1 metal LLW box, aged WG Pu, 3 grams, Solubility Class W DCF, DR = 1

Case B: 1 metal TRU box/SWB, aged WG Pu; 320 grams; Solubility Class W DCF; DR = 1

Accident Consequences

Case A: The radiological dose consequences of a spill involving 1 metal LLW box is *low* to the MOI (9.6E-4 rem @ 1,200 m, 3.4E-4 rem @ 2,367 m), and *low* to the CW (4.7E-2 rem). The resulting risk class is Risk Class III for both the MOI and CW (*anticipated* frequency, *low* consequences).

Case B: The radiological dose consequences of a spill involving one TRU waste box/SWB are *low* (0.1 rem @ 1,200 m and 3.7E-2 rem @ 2,367 m) to the MOI and *moderate* (5.0 rem) to the CW. The resulting risk class for the scenario is Risk Class III for the MOI (*anticipated* frequency, *low* consequences) and Risk Class I for the CW (*anticipated* frequency, *moderate* consequences).

For the IW located in the vicinity at the time of the event, the drop/fall of a waste box could result in serious injury to those either driving the forklift or standing nearby. The radiological dose consequences to the IW are qualitatively judged to be *low* due to: (1) the limited radiological material that is released due to ***container fissile material loading*** limits; (2) the indicators of an accident (*i.e.*, noise, verbal warnings, etc.) that inform the IW of the event; and (3) building ***emergency response*** and ***radiation protection*** guidance that directs the IW to evacuate. These controls mitigate the consequences of the event to the IW. The resulting risk class for this scenario is Risk Class III to the IW (*anticipated* frequency, *low* consequences).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 1: Case A
Metal LLW Box Drop
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.00E-04

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 9.6E-04 |
| One | 4.7E-05 | 9.6E-07 |
| Two | 9.3E-08 | 1.9E-09 |
| Three | 1.9E-10 | 3.9E-12 |
| Four | 3.7E-13 | 7.7E-15 |

**Spill Scenario 1 - Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 1: Case A
Metal LLW Box Drop
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.00E-04

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 3.4E-04 |
| One | 4.7E-05 | 3.4E-07 |
| Two | 9.3E-08 | 6.9E-10 |
| Three | 1.9E-10 | 1.4E-12 |
| Four | 3.7E-13 | 2.7E-15 |

**Spill Scenario 1 - Case A; Radiological Dose Consequences; 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 1: Case B
TRU Box/SWB Drop
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 5.0E+00 | 1.0E-01 |
| One | 5.0E-03 | 1.0E-04 |
| Two | 1.0E-05 | 2.1E-07 |
| Three | 2.0E-08 | 4.1E-10 |
| Four | 4.0E-11 | 8.2E-13 |

Respirable Initial Source Term (g) = 3.20E-02

**Spill Scenario 1 - Case B; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 1: Case B
TRU Box/SWB Drop
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 5.0E+00 | 3.7E-02 |
| One | 5.0E-03 | 3.7E-05 |
| Two | 1.0E-05 | 7.3E-08 |
| Three | 2.0E-08 | 1.5E-10 |
| Four | 4.0E-11 | 2.9E-13 |

Respirable Initial Source Term (g) = 3.20E-02

**Spill Scenario 1 - Case B; Radiological Dose Consequences; 2,367 m**

**Table 8-10** Spill Scenario 1, Case A - LLW Box Drop/Fall

| | |
|---|---|
| Hazard | 4B (Contaminated Radioactive Waste) |
| Accident Type | Spill involving a LLW box; spill occurs during container movement<br>Effective MAR = 3 grams of aged WG Pu<br>Accident can occur in waste storage areas where waste containers are stacked above a first tier |
| Cause or Energy Source | [energy sources] 7A (Vehicles, Material Handling Equipment), 8A (Raised or Suspended Loads/Materials), and 8B (Stacked Waste Containers) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Anticipated | Not Applicable | @ 1,200 m<br>Low<br>9.6E-4 rem<br>@ 2,367 m<br>Low<br>3.4E-4 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>D | P<br>M<br>P | AOL 1<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Anticipated | Not Applicable | Low<br>4.7E-2 rem | Not Applicable | III | Same as MOI | | | |
| IW | Anticipated | Anticipated | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Radiation Protection<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>M<br>M<br>M<br>P/M<br>M | AOL 1<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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# Table 8-11 Spill Scenario 1, Case B - TRU Waste Box/SWB Drop/Fall

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Spill involving one TRU waste box; spill occurs container movement<br>Effective MAR = 320 grams of aged WG Pu<br>Accident can occur in waste storage areas where waste boxes/SWBs are stacked above a first tier |
| Cause or Energy Source | [energy sources] 7A (Vehicles, Material Handling Equipment), 8A (Raised or Suspended Loads/Materials), and 8B (Stacked Waste Containers) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Anticipated | Not Applicable | @ 1,200 m<br>Low<br>0.1 rem<br>@ 2,367 m<br>Low<br>3.7E-2 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>D | P<br>M<br>P | AOL 1<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Anticipated | Not Applicable | Moderate<br>5.0 rem | Not Applicable | I | Same as MOI | | | |
| IW | Anticipated | Anticipated | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Radiation Protection<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>M<br>M<br>M<br>P/M<br>M | AOL 1<br>AOL 4<br>AC 5.5<br>AC 5.<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

### 8.2.3 Spill Scenario 2 – Waste Container Puncture by Forklift Tine

This accident scenario is discussed below and is summarized in Tables 8-12 and 8-13. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

A radioactive material (*Hazard/Energy Source 4B*) spill is postulated to occur as a result of puncturing one or two waste containers. The puncture of the container(s) can occur as a result of the container being impacted and punctured by material handling equipment (*Hazard/Energy Source 7A*) while loading, unloading, or transferring the container from its receipt/shipment area to its staging/storage area.

Based on the MAR values in Table 8-9, the bounding container type for LLW is the box (1 LLW box = 3 grams WG Pu equivalent versus 2 LLW drums = 1 gram WG Pu equivalent); and the bounding container type for TRU waste is the drum (2 drums = 400 grams WG Pu equivalent versus 1 box/SWB = 320 grams WG Pu equivalent). The ARF, RF, DR, and accident frequency are the same for each of the waste container types; therefore the potential effective MAR involved in the event is the deciding factor.

Two cases are evaluated for this scenario. Case A involves the puncture of a metal LLW box. Case B involves the puncture of two adjacent TRU waste drums on a pallet. A portion of the contents of the punctured waste container(s) is postulated to "flow" through the breach onto the ground/floor. Therefore, this puncture-induced spill is analyzed as an unconfined material release (*i.e.*, ARF of 1.0E-3, RF of 1). The spill from the puncture is a short duration event and a minimum release (10 minutes) is analyzed.

*Scenario Modeling Assumptions*: Case A and Case B: spill due to puncture; unconfined material; 10 minute duration.

Accident Frequency

Punctures by forklift tines are considered *anticipated* without prevention. By crediting ***container integrity*** and forklift operator ***training***, this scenario becomes *unlikely*.

*Scenario Modeling Assumptions*: *unlikely* event for both cases.

Material-At-Risk

Case A: A single metal LLW box is involved in this container puncture event. No more than 3 grams WG Pu equivalent will be packaged in a LLW box. This is imposed as a ***container fissile material loading*** limitation

Case B: Two adjacent TRU drums are involved in this container puncture event. No more than 200 grams WG Pu equivalent will be packaged in a TRU waste drum. This is imposed as a ***container fissile material loading*** limitation

For a puncture of either a LLW box or two TRU drums, it is conservatively assumed that 10% of the material exits the waste container(s) following the removal of the forklift tines from the container(s). The involvement of 10% of a waste container inventory is judged to be conservative based on the following considerations: (1) a forklift tine puncture only creates a small breach of the container, (2) few, if any, non-liquid wastes would "flow" out of the container through the breach, (3) any packaging (plastic) in the container will tend to inhibit the "flow" of waste due to recovery from the breach rather than having permanent deformation as might be the case with the metal container wall, and (4) waste material that is capable of "flowing" is most likely to clog at the exit before much material has passed through the container hole. A Solubility Class W DCF is used in modeling both cases of this scenario.

*Scenario Modeling Assumptions*:

Case A: 1 LLW box; aged WG Pu; 3 grams; Solubility Class W DCF; DR = 0.1.

Case B: 2 TRU drums; aged WG Pu; 400 grams; Solubility Class W DCF; DR = 0.1.

Accident Consequences

Case A: The radiological dose consequences for LLW container punctures, based on the effective MAR as discussed above, are *low* (9.6E-04 rem @ 1,200 m and 3.4E-4 rem @ 2,367 m) for the MOI and *low* (4.7E-2 rem) for the CW. The resulting risk classes for the scenario are Risk Class III for both the MOI and the CW (*unlikely* frequency, *low* consequences).

Case B: The radiological dose consequences for TRU waste container punctures, based on the effective MAR as discussed above, are *moderate* (0.13 rem) for the MOI @ 1,200 m, *low* (4.6E-2 rem) for the MOI @ 2,367 m, and *moderate* (6.2 rem) for the CW. The resulting risk class for the scenario is Risk Class II for the MOI @ 1,200 m (*unlikely* frequency, *moderate* consequences), Risk Class III for the MOI @ 2,367 m (*unlikely* frequency, *low* consequences), and Risk Class II for the CW (*unlikely* frequency, *moderate* consequences).

For the IW located in the vicinity at the time of the event, the puncture event could result in serious injury to those either driving the forklift or standing nearby. The radiological dose consequences of the IW are qualitatively judged to be *low* due to: (1) the limited radiological material that is released due to ***container fissile material loading*** limits; (2) the indicators of an accident (*i.e.*, noise, verbal warnings, etc.) that inform the IW of the event; and (3) building ***emergency response*** and ***radiation protection*** guidance that directs the IW to evacuate. These controls mitigate the consequences of the event to the IW. The resulting risk class for both cases is Risk Class III to the IW (*unlikely* frequency, *low* consequences).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 2 | Uncon Non-com |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 2: Case A
LLW Box Puncture
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E-01 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 |
| Public χ/Q (s/$m^3$) = | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 9.6E-04 |
| One | 4.7E-05 | 9.6E-07 |
| Two | 9.3E-08 | 1.9E-09 |
| Three | 1.9E-10 | 3.9E-12 |
| Four | 3.7E-13 | 7.7E-15 |

Respirable Initial Source Term (g) = 3.00E-04

**Spill Scenario 2 - Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 2 | Uncon Non-com |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 2: Case A
LLW Box Puncture
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E-01 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 |
| Public χ/Q (s/$m^3$) = | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 3.4E-04 |
| One | 4.7E-05 | 3.4E-07 |
| Two | 9.3E-08 | 6.9E-10 |
| Three | 1.9E-10 | 1.4E-12 |
| Four | 3.7E-13 | 2.7E-15 |

Respirable Initial Source Term (g) = 3.00E-04

**Spill Scenario 2 - Case A; Radiological Dose Consequences; 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 2 | Uncon Non-com |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 4.00E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:

Spill Scenario 2: Case B
TRU Drum Puncture (2 Drums)
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 4.00E+01 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 4.00E-02

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 6.2E+00 | 1.3E-01 |
| One | 6.2E-03 | 1.3E-04 |
| Two | 1.2E-05 | 2.6E-07 |
| Three | 2.5E-08 | 5.1E-10 |
| Four | 5.0E-11 | 1.0E-12 |

**Spill Scenario 2 - Case B; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 2 | Uncon Non-com |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 4.00E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:

Spill Scenario 2: Case B
TRU Drum Puncture (2 Drums)
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 4.00E+01 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 4.00E-02

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 6.2E+00 | 4.6E-02 |
| One | 6.2E-03 | 4.6E-05 |
| Two | 1.2E-05 | 9.1E-08 |
| Three | 2.5E-08 | 1.8E-10 |
| Four | 5.0E-11 | 3.7E-13 |

**Spill Scenario 2 - Case B; Radiological Dose Consequences; 2,367 m**

# Table 8-12 Spill Scenario 2, Case A - LLW Box Puncture by Forklift Tines

| Hazard | 4B (Radioactive Materials/Waste Container) |
|---|---|
| Accident Type | Puncture of metal LLW box<br>Effective MAR = 3 grams of aged WG Pu; accident can occur in waste storage areas and receipt/shipment areas |
| Cause or Energy Source | [energy sources] 7A (Vehicles, Material Handling Equipment) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | Not Applicable | @ 1,200 m<br>Low<br>9.6E-4 rem<br>@ 2,367 m<br>Low<br>3.4E-4 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>C | P<br>M<br>P | AOL 1<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Unlikely | Not Applicable | Low<br>4.7E-2 rem | Not Applicable | III | Same as MOI | | | |
| IW | Anticipated | Unlikely | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Radiation Protection<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>M<br>M<br>M<br>P/M<br>M | AOL 1<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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### 8.2.4 Spill Scenario 3 –Waste Container Puncture by Compressed Gas Cylinder Missile

This accident scenario is discussed below and is summarized in Tables 8-14 and 8-15. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

A radioactive material (*Hazard/Energy Source 4B*) spill is postulated to occur as a result of puncturing one or more waste containers. The puncture event is postulated to occur as a result of an airborne compressed gas cylinder (*Hazard/Energy Source 6C*) impacting the container(s) causing them to breach. A compressed gas cylinder can become an airborne missile when the cylinder valve is accidentally sheared off during handling/changeout. This event can occur in the staging/storage areas as well as dock areas.

It is further postulated that an airborne compressed gas cylinder can puncture up to three TRU waste drums or one metal LLW box. Based on the MAR values in Table 8-9, the bounding container type for LLW is the box (1 LLW box = 3 grams WG Pu equivalent versus 3 LLW drums = 1.5 grams WG Pu equivalent); and the bounding container type for TRU waste is the drum (3 drums = 600 grams WG Pu equivalent versus 1 box/SWB = 320 grams WG Pu equivalent). The ARF, RF, DR, and accident frequency are the same for each of the waste container types; therefore the potential effective MAR involved in the event is the deciding factor.

Two cases are evaluated for this scenario. Case A involves the puncture of one metal LLW box. Case B involves the puncture of three TRU waste drums. This puncture-induced spill is analyzed as a confined material release (*i.e.*, ARF of 1.0E-3, RF of 0.1) because it is assumed that the contents are not ejected from the container(s). The spill is a short duration event and a minimum release (10 minutes) is analyzed.

*Scenario Modeling Assumptions*: spill due to puncture; confined material; 10 minute duration.

Accident Frequency

Without controls, punctures caused by compressed gas cylinders are considered *unlikely* events based on contributing factors that can cause a cylinder to become an airborne missile. Contributing factors include (1) operator error resulting in a valve cap being removed during handling or storage (procedure violation); (2) failure of personnel to detect a loose or missing cap; (3) an initiating event that causes an uncontrolled or unrestrained cylinder to topple, shearing off the cylinder valve; and (4) the airborne cylinder being stored away from nearby waste containers. With operator ***training*** on safe storage and handling of compressed gas cylinders, the puncture scenario becomes an *extremely unlikely* event.

*Scenario Modeling Assumptions*: *extremely unlikely* event.

## Table 8-13 Spill Scenario 2, Case B - TRU Drum Puncture by Forklift Tines

| Hazard | 4B (Radioactive Materials/Waste Container) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Accident Type | Puncture of two 55-gallon TRU waste drums<br>Effective MAR = 40 grams of aged WG Pu (DR = 0.1); accident can occur in waste storage areas and receipt/shipment areas | | | | | | | | | |
| Cause or Energy Source | [energy sources] 7A (Vehicles, Material Handling Equipment) | | | | | | | | | |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA | | | | | | | | | |
| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | Not Applicable | @ 1,200 m<br>Moderate 0.13 rem<br>@ 2,367 m<br>Low 4.6E-2 rem | Not Applicable | @ 1,200 m<br>II<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>C | P<br>M<br>P | AOL 1<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Unlikely | Not Applicable | Moderate 6.2 rem | Not Applicable | II | Same as MOI | | | |
| IW | Anticipated | Unlikely | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Radiation Protection<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>M<br>M<br>M<br>P/M<br>M | AOL 1<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

Material-At-Risk

Case A: A single metal LLW box is involved in this container puncture event. No more than 3 grams WG Pu equivalent will be packaged in a LLW box. This is imposed as a ***container fissile material loading*** limitation.

Case B: Three TRU drums are involved in the container puncture event. No more than 200 grams WG Pu equivalent will be packaged in a TRU waste drum. This is imposed as a ***container fissile material loading*** limitation. (3 drums = 600 grams).

A Solubility Class W DCF is conservatively used in modeling both cases of this scenario because less than 30 containers are postulated to be involved. Guidance on when to use Solubility Class W DCFs can be found in Ref. 36)

*Scenario Modeling Assumptions*:

Case A: 1 LLW box; aged WG Pu; 3 grams; Solubility Class W DCF; DR = 1.

Case B: 3 TRU drums; aged WG Pu; 600 grams; Solubility Class W DCF; DR = 1.

Accident Consequences

Case A: The radiological dose consequences for this LLW container puncture, based on the effective MAR as discussed above, are *low* (9.6E-04 rem @ 1,200 m and 3.4E-4 rem @ 2,367 m) for the MOI and *low* (4.7E-2 rem) for the CW. The resulting risk classes for the scenario are Risk Class IV for both the MOI and the CW (*extremely unlikely* frequency, *low* consequences).

Case B: The radiological dose consequences for TRU waste container punctures, based on the effective MAR as discussed above, are *moderate* (0.19 rem) for the MOI @ 1,200 m, *low* (6.9E-2 rem) for the MOI @ 2,367 m, and *moderate* (9.3 rem) for the CW. The resulting risk class for the scenario is Risk Class III for the MOI @ 1,200 m (*extremely unlikely* frequency, *moderate* consequences), Risk Class IV for the MOI @ 2,367 m (*extremely unlikely* frequency, *low* consequences), and Risk Class III for the CW (*extremely unlikely* frequency, *moderate* consequences).

For the IW located in the vicinity at the time of the event, the puncture event could result in serious injury to the operator handling the gas cylinder or someone working in the room. The radiological dose consequences of the IW are qualitatively judged to be *low* due to: (1) the limited radiological material that is released due to ***container fissile material loading*** limits; (2) the indicators of an accident (*i.e.*, noise, verbal warnings, etc.) that inform the IW of the event; and (3) building ***emergency response*** and ***radiation protection*** guidance that directs the IW to evacuate. These controls mitigate the consequences of the event to the IW. The resulting risk class for both cases is Risk Class IV to the IW (*extremely unlikely* frequency, *low* consequences).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Spill Scenario 3: Case A
LLW Box Puncture - Compressed Gas Missile
1 Metal LLW Box
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.00E-04

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 9.6E-04 |
| One | 4.7E-05 | 9.6E-07 |
| Two | 9.3E-08 | 1.9E-09 |
| Three | 1.9E-10 | 3.9E-12 |
| Four | 3.7E-13 | 7.7E-15 |

**Spill Scenario 3 - Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Spill Scenario 3: Case A
LLW Box Puncture - Compressed Gas Missile
1 LLW Box
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.00E-04

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 3.4E-04 |
| One | 4.7E-05 | 3.4E-07 |
| Two | 9.3E-08 | 6.9E-10 |
| Three | 1.9E-10 | 1.4E-12 |
| Four | 3.7E-13 | 2.7E-15 |

**Spill Scenario 3 - Case A; Radiological Dose Consequences; 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 6.00E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 3: Case B
TRU Drum Puncture - Compressed Gas Missile
3 TRU Drums
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 6.00E+02 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 6.00E-02

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E-01 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 9.3E+00 | 1.9E-01 |
| One | 9.3E-03 | 1.9E-04 |
| Two | 1.9E-05 | 3.9E-07 |
| Three | 3.7E-08 | 7.7E-10 |
| Four | 7.5E-11 | 1.5E-12 |

**Spill Scenario 3 - Case B; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 6.00E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 3: Case B
TRU Drum Puncture - Compressed Gas Missile
3 TRU Drums
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 6.00E+02 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 6.00E-02

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E-01 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 9.3E+00 | 6.9E-02 |
| One | 9.3E-03 | 6.9E-05 |
| Two | 1.9E-05 | 1.4E-07 |
| Three | 3.7E-08 | 2.7E-10 |
| Four | 7.5E-11 | 5.5E-13 |

**Spill Scenario 3 - Case B; Radiological Dose Consequences; 2,367 m**

## Table 8-14 Spill Scenario 3, Case A - LLW Box Puncture by Compressed Gas Missile

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container) |
| **Accident Type** | Puncture of metal LLW box<br>Effective MAR = 3 grams of aged WG Pu; accident can occur in waste storage areas and receipt/shipment areas |
| **Cause or Energy Source** | [energy sources] 6C (Compressed Gas Cylinders) |
| **Applicable Activity(ies)** | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Extremely Unlikely | Not Applicable | @ 1,200 m<br>Low<br>9.6E-4 rem<br>@ 2,367 m<br>Low<br>3.4E-4 rem | Not Applicable | @ 1,200 m<br>IV<br>@ 2,367 m<br>IV | Container Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>C | P<br>M<br>P | AOL 1<br>AOL 4<br>AC 5.6 |
| CW | Unlikely | Extremely Unlikely | Not Applicable | Low<br>4.7E-2 rem | Not Applicable | IV | Same as MOI | | | |
| IW | Unlikely | Extremely Unlikely | Not Applicable | Low | Not Applicable | IV | Container Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Radiation Protection<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>M<br>M<br>M<br>P/M<br>M | AOL 1<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 8-15 Spill Scenario 3, Case B - TRU Drum Puncture by Compressed Gas Missile

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Puncture of two 55-gallon TRU waste drums<br>Effective MAR = 40 grams of aged WG Pu (DR = 0.1); accident can occur in waste storage areas and receipt/shipment areas |
| Cause or Energy Source | [energy sources] 6C (Compressed Gas Cylinders) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Extremely Unlikely | Not Applicable | @ 1,200 m<br>Moderate<br>0.19 rem<br>@ 2,367 m<br>Low<br>6.9E-2 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>IV | Container Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>C | P<br>M<br>P | AOL 1<br>AOL 4<br>AC 5.6 |
| CW | Unlikely | Extremely Unlikely | Not Applicable | Moderate<br>9.3 rem | Not Applicable | III | Same as MOI | | | |
| IW | Unlikely | Extremely Unlikely | Not Applicable | Low | Not Applicable | IV | Container Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Radiation Protection<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>M<br>M<br>M<br>P/M<br>M | AOL 1<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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### 8.2.5 Control Set Vulnerability

Two preventive features have been credited in the determination of spill scenario frequencies and three mitigative features have been credited in determination of spill scenario consequences.

The credited preventive features are:

1. the ***container integrity*** administrative control (all receptors); and
2. the administrative control for ***training*** of forklift operators (Spill Scenario 2) and personnel handling compressed gas cylinders (Spill Scenario 3) (all receptors).

The credited mitigative features are:

1. the ***container fissile material loading*** administrative control (all receptors);
2. the ***radiation protection*** administrative control (IW only); and
3. the ***emergency response*** administrative control (IW only).

Failure of the ***container integrity*** preventive feature (*e.g.*, inadequate container) increases the likelihood that a waste container will breach due to a drop/fall from heights less than four feet. The likelihood of a breach due to a container drop/fall from less than four feet is considered *beyond extremely unlikely* if the container specifications are met. The less than 4 foot drop breach likelihood could increase to an *anticipated* event if the metal container does not meet specified requirements. Failure of this feature would also increase the likelihood that a waste container puncture will occur due to a forklift tine impact. The likelihood of a breach due to this container puncture is considered an *unlikely* event if the container specifications are met. The puncture scenario becomes an *anticipated* event if the metal container does not meet specified requirements.

Failure of the ***training*** preventive feature (*i.e.*, personnel not trained on the proper use of handling equipment (forklifts)) could increase the likelihood that an operator error results in forklift tines causing a container puncture. The likelihood of a breach due to a container puncture from a forklift tine is considered an *unlikely* event if the forklift operators are adequately trained. Failure of the ***training*** protective feature results in the forklift tine puncture scenario becoming an *anticipated* event. Failure of the ***training*** preventive feature will also increase the likelihood that a waste container puncture will occur due to impact by an airborne compressed gas cylinder. The likelihood of a breach due to an airborne compressed gas cylinder is considered *extremely unlikely* if personnel are trained on the safe handling and storage of compressed gas cylinders. This puncture scenario becomes *unlikely* if the operators are not adequately trained.

Failure of the ***container fissile material loading*** mitigative feature (*e.g.*, underestimation of container radiological inventory, over batching, etc.) would result in additional MAR and a corresponding increase in the radiological dose consequences to all receptors.

Failures of the ***radiation protection*** or the ***emergency response*** SMPs (inadequate response to radioactive material spill) can result in increased IW exposure to airborne radioactive materials. This can increase the spill scenario consequences for the IW from *low* to *moderate* due to the higher radiological dose associated with a longer exposure time.

In the situations discussed above, the following defense-in-depth features tend to mitigate or prevent the scenario but are not credited in the analysis:

- ***Training*** (all receptors): The ***training*** program is an additional preventive feature that can potentially reduce the likelihood of spill and puncture scenarios.
- ***Training*** (IW only): In addition to the preventive features of the ***training*** program identified above, the IW ***training*** program is an additional mitigative feature that can reduce IW consequences as a reinforcement of ***emergency response*** evacuation guidance.
- ***LS/DW*** (IW only): Facility management or other personnel can utilize the ***LS/DW system*** to reduce IW consequences by announcing the spill to facility personnel.

### 8.2.6 Spill Scenario Assumptions

In the evaluation of the spill scenarios, assumptions are identified for prevention and/or mitigation of the accidents. Table 8-16 presents a listing of the assumptions specified in the evaluation of spill scenarios. The scenarios/cases to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 8-16** Spill Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| LLW containers contain no more than 0.5 grams WG Pu equivalent in drums and 3 grams WG Pu equivalent in metal boxes. | Spill Scenario 1, Case A | Sets the potential MAR for the scenario impacting LLW containers.<br>***ContainerFissile Material Loading*** |
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs. | Spill Scenario 1, Case B | Sets the potential MAR for the scenario impacting TRU waste containers.<br>***Container Fissile Material Loading*** |
| A pallet of waste drums contains no more than 4 drums. | Spill Scenarios 1, 2, and 3 | Sets the potential MAR for the scenario. |
| A drop/fall of banded waste drums results in the equivalent release of material of one waste drum. | Spill Scenarios 1, 2, and 3 | Sets the potential MAR for the scenario impacting banded waste drums.<br>***Container Stacking (Banding)*** |

**Table 8-16** Spill Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| Metal waste containers are *unlikely* to be breached by non-forklift tine impacts from material handling equipment expected during operation. | Spill Scenarios 1, 2, and 3 | Reduces the likelihood of metal waste container failure from scenarios dealing with dropped containers by one frequency bin. ***Container Integrity*** |
| Metal waste containers cannot be breached by falls less than four feet. | Spill Scenarios 1, 2, and 3 | Reduces the likelihood of metal waste container failure due to dropping from less than four feet to *Beyond Extremely Unlikely*. ***Container Integrity*** |
| Metal drums stacked above the second tier will be banded. | Spill Scenario 1, Case B | Reduces the effective MAR of the scenario due to a pallet of TRU waste container dropping or falling from the third or fourth tier of the stack. ***Container Stacking (Banding)*** |
| Only 2 drums can be impacted by forklift tines. | Spill Scenario 2, Case B | Sets the potential MAR for the scenario. |
| Metal waste containers are *unlikely* to be breached by forklift tine impacts due to impact angle requirements needed to lead to failure. | Spill Scenario 2, Case B | Reduces the likelihood of waste container failure dealing with forklift tines impacting containers by one frequency bin. ***Container Integrity*** |
| It is *beyond extremely unlikely* to breach a POC or Type B container by forklift tine impacts due to impact angle requirements needed to lead to failure. | Spill Scenario 2 | Reduces the likelihood of POC or Type B container failure dealing with forklift tines impacting containers by two frequency bins. ***Container Integrity (POC/Type B Container)*** |
| The Waste Management Facilities will comply with the Radiation Protection program. | Spill Scenarios 1, 2, and 3 | Reduces the exposure to the IW to releases. ***Radiation Protection*** |
| The Waste Management Facilities will develop facility-specific Emergency Plans. | Spill Scenarios 1, 2, and 3 | Reduces the exposure to the IW to releases. ***Emergency Response*** |

## 8.3 EXPLOSION SCENARIO ACCIDENT ANALYSIS

### 8.3.1 Explosion Scenario Development and Selection

The analyzed explosion scenario is an internal hydrogen explosion of a metal TRU waste container due to the accumulation of hydrogen gas inside the container. LLW waste does not generate sufficient quantities of hydrogen to cause an internal explosion (Ref. 37). The MAR values associated with the container types evaluated in the explosion scenarios are presented in Table 8-17.

**Table 8-17** Explosion Scenario MAR Values

| CONTAINER TYPE | CONTAINER CONFIGURATION | MAXIMUM MAR (WG Pu equivalent) | EFFECTIVE MAR (WG Pu equivalent) |
|---|---|---|---|
| TRUPACT II SWB or metal waste box | single | 320 grams | 320 grams |
| TRU drum | single | 200 grams | 200 grams |

**8.3.1.1** Internal Explosion: TRU Waste Container

The SARAH (Ref. 9) specifically addresses container overpressurization due to internal hydrogen explosions. Based on industry tests cited in the SARAH, drum lids will separate from the drum if drum free volume gases containing greater than 15% hydrogen and 7.5% oxygen, by volume, are ignited. Aqueous sludge waste containers at the Site have been sampled and found to contain as much as 14.5% hydrogen and sufficient oxygen to completely burn the hydrogen.

A typical waste container is expected to contain most of the gases in the head space above the solid materials. Polyethylene bags surrounding the solid materials may be deteriorated, but would likely provide some protection from the explosion of the head space gases. While some gases may occupy spaces within the solid material, the majority is assumed to be located in the head space area of the container. Most of the explosive force will be in the direction of the separated lid and away from the solid material in the container. Therefore, only a fraction of the solid material in the container would be subjected to the overpressure transient in a manner that would lead to a release. A concurrent fire involving the waste container contents is judged not to occur following the overpressurization and lid loss due to the rapidity and low energy of the excursion (Ref. 38).

**8.3.1.3** Representative Explosion Scenario

The representative explosion scenario evaluated for waste management facility SH activities are:

- Explosion Scenario 1 – TRU Waste Container Explosion



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### 8.3.2 Explosion Scenario 1 - TRU Waste Container Explosion

This accident scenario is discussed below and is summarized in Table 8-18. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

Hydrogen generation in metal waste containers (*Hazard/Energy Source 13A*) is postulated to lead to an internal hydrogen explosion in a TRU waste container (*Hazard/Energy Source 4B*). The radioactive decay of the TRU waste material interacts with hydrogenous waste materials and produces hydrogen and oxygen gases. The gases are retained in the metal waste container and accumulate to the point where a hydrogen explosion potential exists. Since it is assumed that a static charge can ignite flammable hydrogen/oxygen mixtures, static charges generated by container movements ignite the hydrogen. Therefore, the container explosion can occur at any point in the handling of the container (*i.e.*, at the storage location, at the dock, and during transfer). Since the container loses its lid as part of the scenario, the material impacted by the event is no longer confined. The scenario deals with an overpressure event that is conservatively assumed to impact radioactive material in the form of a powder. The scenario is modeled as a 10 minute release. A ground-level (non-lofted) release of the radioactive material is assumed.

*Scenario Modeling Assumptions:* internal overpressure; powder; unconfined combustible material;10 minute duration.

Accident Frequency

The postulated accident scenario is considered to be an *unlikely* event without prevention. The scenario becomes *extremely unlikely* when crediting the ***vented containers*** and ***inventory control and material management program*** administrative controls.

The ***vented containers*** control precludes the accumulation of hydrogen in the waste container as long as the vent remains open except for cases of extremely high hydrogen generation rates as might be associated with a chemical reaction occurring in the container rather than just radiolysis. Since the distance through the filter is short relative to the diameter of the filter, the migration of hydrogen through the vent is not vent limited as might be the case for vented tanks with long vent lines. The driving force for the hydrogen in the container is primarily the buoyancy of the hydrogen gas relative to air. The equilibrium concentration of hydrogen gas in a vented TRU waste container is expected to be well below the 15% hydrogen concentration levels needed to cause a breach of the waste container.

The likelihood of the event is dependent on: (1) the hydrogen generation rate based upon the amount of radioactive and hydrogenous material in the container; (2) the extent to which the vent is plugged that impacts the ability of the container to retain the hydrogen; and (3) the length of time that the container vent is plugged relative to the container hydrogen generation rate. The hydrogenous materials may be in the form of plastics and paper, but waste containers with liquids that can lead to significant hydrogen generation are restricted from waste management facilities by an ***inventory control and material management program***. Vent plugging has been observed in containers with reactive chemical components (*e.g.*, acids) where the fumes from the chemicals can act on the vent leading to corrosion product buildup. Since liquids that can lead to metal waste container vent plugging are restricted from waste management facilities by an ***inventory control and material management program,*** the extent of reactive chemicals in TRU waste is limited, which reduces the likelihood of vent plugging.

*Scenario Modeling Assumptions: extremely unlikely* event.

Material-At-Risk

Only a single TRU waste container is involved in the container explosion event. Multiple contiguous vented waste containers having explosive concentrations of hydrogen and oxygen accumulated in the containers is considered to be *beyond extremely unlikely*. This scenario assumes that not more than 320 grams (WG Pu equivalent) of radioactive material will be in a TRU waste box, as imposed by ***container fissile material loading*** limits. The container involved in the explosion event is conservatively assumed to be Solubility Class W material.

As stated earlier, not all of the solid material in the waste container is impacted by the explosion since the predominance of gases are located at the top of the container in the head space and most of the force of the explosion would be in the direction of the container lid loss. The SARAH (Ref. 9) recommends that a small damage ratio be used for the internal waste container hydrogen explosion (*i.e.*, DR = 0.1). The DOE Handbook on release fractions (Ref. 39) recommends an ARF value of 0.1 and a RF value of 0.7 for the venting of pressurized gases over contaminated, non-combustible material where the volume is pressurized. The ARF and RF values in the DOE Handbook are based on results of experiments dealing with confinement failures of pressurized containers containing solid material in the form of powder and these values will be conservatively applied to the TRU waste container hydrogen explosion scenario. The unmitigated case does not credit the container or the inner packaging (i.e., DR = 1).

*Scenario Modeling Assumptions:* single container; aged WG Pu; 320 grams; Solubility Class W DCF; DR = 0.1.

Accident Consequence

The analyzed radiological dose consequences of a container explosion involving a single TRU waste box are *high* (7.2 rem) for the MOI @ 1,200 m, *moderate* (2.6 rem) for the MOI @ 2,367 m, and *high* (350 rem) for the CW. The resulting risk class for the scenario is Risk Class II for the MOI @ 1,200 m, Risk Class III for the MOI @ 2,367 m, and Risk Class II for the CW.

The IW located in the vicinity of the container explosion can be seriously injured from the impact of the container lid. There is the potential for the IW to inhale radioactive material being carried in the release plume following the explosion (2.24 grams) but the IW would have to remain in the vicinity or in the path of the plume for a length of time. It would be relatively easy for the IW to evacuate the area with minimum dose impact if the IW is not incapacitated. The radiological dose consequences for the IW are qualitatively judged to be *moderate* due to: (1) the moderate amount of radiological material that is released; (2) the rapid rate of release (*i.e.*, puff release that places all the released material into the air in a very short time); (3) the indicators of the explosion (*e.g.*, loud noise, loss of container lid) that inform the IW of the event; and (4) building ***emergency response*** that directs the IW to evacuate. The resulting risk class for the scenario is Risk Class III for the IW (*extremely unlikely* frequency, *moderate* consequence).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 5 | Overpressure |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Explosion Scenario 1
1 TRU Waste Box
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | N/A | N | 1.0E-01 | 1.0E-01 |
| Respirable Fraction = | N/A | N | 7.0E-01 | 7.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+01 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 2.24E+00

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 3.5E+02 | 7.2E+00 |
| One | 3.5E-01 | 7.2E-03 |
| Two | 7.0E-04 | 1.4E-05 |
| Three | 1.4E-06 | 2.9E-08 |
| Four | 2.8E-09 | 5.8E-11 |

**Explosion Scenario 1 – Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 5 | Overpressure |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Explosion Scenario 1
1 TRU Waste Box
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | N/A | N | 1.0E-01 | 1.0E-01 |
| Respirable Fraction = | N/A | N | 7.0E-01 | 7.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+01 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 2.24E+00

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 3.5E+02 | 2.6E+00 |
| One | 3.5E-01 | 2.6E-03 |
| Two | 7.0E-04 | 5.1E-06 |
| Three | 1.4E-06 | 1.0E-08 |
| Four | 2.8E-09 | 2.0E-11 |

**Explosion Scenario 1 – Radiological Dose Consequences; 2,367 m**



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## Table 8-18 Explosion Scenario 1: TRU Waste Box/SWB Container Explosion

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Container Explosion involving a single TRU waste box/SWB; hydrogen and oxygen accumulate in sealed container and the mixture is ignited by spark<br>Effective MAR = 32 grams of aged WG Pu (10% damage ratio); the accident can occur in waste management facilities where TRU waste containers are handled. |
| Cause or Energy Source | [causes] 13A (Hydrogen Generation in Metal Waste Containers)<br>[energy sources] container movement |
| Applicable Activity(ies) | SH |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Extremely Unlikely | Not Applicable | @ 1,200 m<br>High<br>7.2 rem<br>@ 2,367 m<br>Moderate<br>2.6 rem | Not Applicable | @ 1,200 m<br>II<br>@ 2,367 m<br>III | Vented Containers<br>Liquids in Waste Prohibited<br>Container Fissile Material Loading | C<br>C<br>C | P<br>P<br>M | AOL 3<br>AOL 7<br>AOL 4 |
| CW | Unlikely | Extremely Unlikely | Not Applicable | High<br>350 rem | Not Applicable | II | Same as MOI | | | |
| IW | Unlikely | Extremely Unlikely | Not Applicable | Moderate | Not Applicable | III | Vented Containers<br>Liquids in Waste Prohibited<br>Container Fissile Material Loading<br>Emergency Response<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D | P<br>P<br>M<br>M<br>M<br>M | AOL 3<br>AOL 7<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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### 8.3.3 Control Set Vulnerability

Two preventive features have been credited in the determination of the explosion scenario frequency and two mitigative features have been credited in determination of the explosion scenario consequences.

The credited preventive features are:

1. the ***vented containers*** administrative control, which is applicable to all metal waste containers (all receptors);

2. the ***inventory control and material management program*** administrative control that restricts liquids that can lead to significant hydrogen generation from waste management facilities (all receptors).

The credited mitigative features are:

1. the ***container fissile material loading*** administrative control (all receptors);

2. the ***emergency response*** administrative control (IW only).

Failure of the ***vented containers*** preventive feature (overpressurization of waste container) could result in an increased likelihood (one frequency bin) that a waste container will breach due a hydrogen explosion.

Failure of the ***inventory control and material management program*** could lead to significant hydrogen generation (liquids are present in waste containers), which increases the rate of hydrogen generation and therefore increases the likelihood that a waste container will breach due a hydrogen explosion. Vent plugging has been observed in containers with reactive chemical components (*e.g.*, acids) where the fumes from the chemicals can act on the vent leading to corrosion product buildup.

Failures of the ***container fissile material loading*** mitigative feature (higher MAR containers) would result in additional MAR and a corresponding increase in radiological dose.

Failure of the ***emergency response*** mitigative feature (inadequate emergency plan) could result in additional IW exposure to airborne radioactive materials.

In all situations discussed above, the following defense-in-depth features tend to mitigate or prevent the scenario but are not credited in the analysis:

- ***Training*** (IW only): IW ***training*** is an additional mitigative feature that can reduce IW consequences as a reinforcement of the ***emergency response*** evacuation guidance.

- ***LS/DW*** (IW only): Facility management or other personnel can utilize the ***LS/DW system*** to reduce IW consequences by announcing the container explosion to facility personnel.



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### 8.3.4 Explosion Scenario Assumptions

In the evaluation of the container explosion scenario, assumptions are identified for prevention and/or mitigation of the accident. Table 8-19 presents a listing of the assumptions specified in the accident evaluation. The scenario(s) to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 8-19** Explosion Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs.. | Explosion Scenario 1 | Sets the potential MAR for the explosion scenarios impacting waste containers (200 grams for TRU waste drums and 320 grams for metal boxes/SWBs)<br>***Container Fissile Material Loading*** |
| Metal waste containers are *extremely unlikely* to be breached by internal hydrogen explosions due to metal waste container venting. | Explosion Scenario 1 | Reduces the likelihood of metal waste container failure for scenarios dealing with internal hydrogen explosions by two frequency bins.<br>***Vented Containers*** |
| Waste Management Facilities will develop facility-specific Emergency Plans. | Explosion Scenario 1 | Reduces the exposure time for the IW.<br>***Emergency Response*** |
| Waste containers to be stored in waste management facilities shall not contain liquids. | Explosion Scenario 1 | Reduces the likelihood of internal hydrogen explosions in containers by reducing the potential rate of hydrogen generation.<br>***Inventory Control and Material Management Program - Liquids in Waste Prohibited*** |



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## 8.4 NATURAL PHENOMENA ACCIDENT ANALYSIS

### 8.4.1 Natural Phenomena Scenario Development and Selection

The natural phenomena hazard (NPH) scenarios evaluated in this section include: (1) seismic events (earthquakes); (2) lightning; (3) high winds and tornadoes; (4) heavy rain, flooding, and freezing events, and (5) heavy snow. DOE Order 420.1, *Facility Safety* (Ref. 40) establishes the policy and requirements for NPH mitigation for DOE sites and facilities. Guidance addressing NPHs is provided in several DOE Standards: DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* (Ref. 41); DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components* (Ref. 42); DOE-STD-1022-94, *Natural Phenomena Hazards Characterization Criteria* (Ref. 43); DOE-STD-1023-94, *Natural Phenomena Hazards Assessment Criteria* (Ref. 44); DOE-STD-1024-92, *Guidelines for Use of Probabilistic Seismic Hazard Curves at DOE Sites* (Ref. 45); and draft standard entitled *Lightning Hazard Management Guide for DOE Facilities* (Ref. 46). Each of the NPHs listed above will be addressed in the following sub-sections.

#### 8.4.1.1 Seismic Events

As discussed in Section 5.12 (*Hazard/Energy Source 13H*), seismic events have the potential to initiate fire, spill, and explosion accidents in waste management facilities. Facility fires following a seismic event may occur, particularly in facilities with significant combustible loading in close proximity to electrical equipment. The likelihood of a seismic-initiated fire in a waste storage area as a result of seismic event is considered *beyond extremely unlikely* due to the combustible material control program, which restricts combustible loading and ignition sources in waste storage areas.

The likelihood of seismic-initiated facility explosions is initially estimated to be *extremely unlikely* as compared to the *unlikely* breach of containers due to structural member impacts and stack toppling. The facility explosion would impact the containers in a similar fashion but with much lower likelihood. For this reason, the contribution of facility explosions to the overall spill consequences following a seismic event is considered to be small and will not be evaluated further.

A design basis earthquake (DBE) for the waste management facilities is an *unlikely* event and could result in a spill scenario. A DBE would result in damage to overhead equipment and material that is not seismically rated. The falling objects result in damage to waste containers in the facility. No waste container damage from toppling stacks is expected to occur during the DBE or lesser earthquakes.

It is assumed that each of the waste storage facilities has a threshold at which structural failure will occur during a strong enough seismic event (*e.g.,* a Beyond Design Basis Earthquake (BDBE)). The occurrence frequency for this type of event is *unlikely* for waste management facilities. For the purposes of this safety analysis, the BDBE is assumed to cause structural failure of the facilities. The most severe damage to waste containers would be realized in substantial and medium construction facilities due to falling overhead debris and structural members. The number



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of waste containers estimated to be damaged by a BDBE is based on the number of containers that would be exposed to absorb the impact of falling objects. Additionally, damage to containers may result from a BDBE with intensity enough to cause drums to topple.

**8.4.1.2** Lightning

Lightning is considered a potential ignition source for facility fires, spills and explosions. Lightning is not expected to yield spill events as significant as structural collapse of a waste storage area/facility and is, therefore, not further evaluated as an accident initiator. Facility explosion scenarios following lightning events are considered *beyond extremely unlikely* events based on the discussions in Section 13.2.2, *Explosion Scenario 2 – External Explosion in Waste Storage Area.* These discussions indicate that numerous failures must occur in conjunction with specific facility configurations for a facility explosion to occur. The likelihood of a lightning strike occurring simultaneously with a specific facility configuration (*i.e,* an explosive atmosphere) resulting in the ignition of a flammable atmosphere is remote and not further evaluated. The frequency of lightning striking a facility and initiating a fire is an *unlikely* event. If a lightning strike occurs and initiates a facility fire, the scenario would be the same as already considered in the facility fire scenarios presented in Section 8.1. Lightning was considered as an initiator of a facility fire and is not evaluated further.

Some facilities are equipped with a lightning protection system intended to reduce the probability that lightning strikes will result in damage to building systems or initiate a fire. However, the condition of the lightning protection systems are generally not known, and although there is no reason to believe the systems are inoperable, they are not credited to provide protection against lightning strikes.

**8.4.1.3** High Winds and Tornadoes

High wind and tornado events have the potential to initiate spills in waste management facilities. High winds and tornadoes have similar, but lesser, impacts on the facility as compared to seismic events. Destructive tornadoes are considered *extremely unlikely* for the Site (Ref. 47). Although tornadoes can occur at the Site, wind speed is an inverse function of frequency, therefore the more frequent ones would be relatively weak. Tornadoes with wind speeds in excess of those of straight winds (for the same probability) are projected to occur only for annual probabilities of exceedance which are less than about 1E-7. The location of the Site near the Front Range of the Rocky Mountains is in a "special wind area" as defined by building codes. The reason for this is that certain weather conditions lead to extremely high winds of fairly frequent occurrence. However, the location is westerly enough so tornado occurrence has a lower probability.

Wind-generated missiles could impact a waste management facility in a high wind or tornado event. Damage to waste containers within the building would occur due to impact by wind-generated missiles, but would impact relatively few containers before all the energy associated with the missile was spent. The frequency and consequence of either earthquake initiated spill scenario, *NPH Scenario 1 - DBE Event-Induced Spill* or *NPH Scenario 2 – BDBE Event-Induced Spill,* bounds wind missile initiated spills because the earthquake has a greater potential to involve more material and has a lower capability to disperse the release than a wind missile scenario. Inherent in the high wind and tornado assumptions is a turbulent atmosphere that would widely disperse any release from a spill. From the meterological discussions in SARAH (Ref. 9), several general rules are cited for application of atmospheric stability class information. The dose consequences calculated for accident scenarios in this NSTR assume 95$^{th}$ percentile weather which represents the "worst-case" weather from a dose consequence standpoint because it would result in very little dispersion of a contaminated plume. Sometimes 50$^{th}$ percentile weather ("median") is used for comparison purposes because it is considered to be more realistic. The 95$^{th}$ percentile to 50$^{th}$ percentile $\chi/Q$ ratio is about ten for both the CW and MOI. Wind gusts of 100 mph are about ten times greater than the wind speed that corresponds with 50$^{th}$ percentile $\chi/Q$. Because the value of $\chi/Q$ varies inversely with wind speed, it follows that the high-wind $\chi/Q$ is about 10% of the 50$^{th}$ percentile $\chi/Q$ and 1% of the 95$^{th}$ percentile $\chi/Q$. Therefore, it would take 100 times the MAR involvement in a high-wind or tornado induced spill event to reach the dose consequence levels of a seismic induced spill. For this reason high wind- or tornado-induced spill scenarios are not further analyzed.

#### **8.4.1.4** Heavy Rain, Flooding, and Freezing

A load can be applied to a building roof due to the amount of rainfall and/or ponding. Ponding of water on waste management facility rooftops is not a concern because they are sloped to allow runoff. The waste management facilities are not located within potential flooding areas of the Site. Any exceptions (*e.g.*, Building 991 Complex) will be addressed in individual facility-specific AB documents. Therefore, flooding events are not further analyzed here.

It is expected that the snow followed by rain event will be similar to and bounded by the snow event described below. Typically, this event would occur in the spring, and would not be accompanied by a hard freeze that would prevent the roof drains from working. Rain is not discussed further.

#### **8.4.1.5** Heavy Snow

A A scenario involving structural damage to the roof of a waste management facility due to snow loads exceeding design capability would result in a spill scenario. Snow is an *anticipated* occurrence in Colorado. Anticipated snow loads will not fail roof structures. Snow loading causing a partial collapse of a roof is estimated to have an *unlikely* frequency. In terms of facility and waste container damage, this scenario is identical the earthquake-initiated spill scenario, *NPH Scenario 1 – DBE Event-Induced Spill* because a snow-induced roof failure spill would involve the same amount of radiological material (from falling overhead equipment/debris). In addition, these scenarios occur in the same frequency bin. Therefore, the risk classes are the same and heavy snow scenarios are not further analyzed.

#### **8.4.1.6** Representative NPH Scenarios

The representative NPH scenarios evaluated for waste management facilities are:

- NPH Scenario 1 – DBE Event-Induced Spill
- NPH Scenario 2 – BDBE Event-Induced Spill



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### 8.4.2 NPH Scenario 1 – DBE Event-Induced Spill

This accident scenario is discussed below and is summarized in Tables 8-22 and 8-23. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text.

Accident Scenario

A DBE event is postulated to impact waste storage areas of medium and substantial construction facilities. Waste containers that are impacted may be breached by falling objects (*e.g.*, overhead cranes; heating, ventilating, and air conditioning (HVAC) ducts; lights, etc.) and other overhead equipment that is not seismically rated. The building structure and roof is expected to remain intact in a DBE event. In addition, stacked waste containers are not expected to topple in a DBE event due to ***container stacking (banding)*** requirements. The exposed upper tier of waste containers is assumed to be susceptible to impact from falling objects. There is no source of heavy falling objects in light construction facilities or open storage areas. The breached containers do not spill their contents because the breach is at the top or upper portion of the container. Since the breaches do not result in radioactive material "flowing" from the breach, as is the case in the forklift tine puncture of containers (see Section 8.2.1.3, *Container: Puncture*), these container breaches are analyzed as a confined material releases. A ground-level (non-lofted) release of the radioactive material is assumed. The spill is a short duration event and a minimum duration release (10 minutes) is analyzed. Two cases are evaluated, one each for medium and substantial construction facilities.

*Scenario Modeling Assumptions*: spill; confined material; 10 minute duration.

Accident Frequency

The likelihood of this postulated accident scenario is *unlikely* based upon seismic history of the region (Ref. 2). As stated above, a concurrent fire with the DBE is considered *beyond extremely unlikely* due to the credited ***fuel/combustible loading and ignition source control*** program that limits the amount of combustibles in waste storage areas.

*Scenario Modeling Assumptions*: *unlikely* event.

Material-At-Risk

The MAR values associated with the container types evaluated in the seismic scenarios are presented in Table 8-20. These MAR values are used to determine the bounding container types for the representative seismic scenarios.



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**Table 8-20** Seismic Event MAR Values

| CONTAINER TYPE | CONTAINER CONFIGURATION | MAR (WG Pu equivalent per involved container) |
|---|---|---|
| Metal LLW box | multiple | 3 grams |
| LLW drum | multiple | 0.5 grams |
| LLW drum (95th % UCL value plus conservatism) | multiple | 0.24 grams |
| TRUPACT II SWB or metal waste box | multiple | 320 grams |
| TRU drum | multiple | 200 grams |
| TRU drum (95th % UCL value plus conservatism) | multiple | 114 grams |

There are no medium or substantial construction facilities that store exclusively LLW, therefore a DBE event would involve a combination of LLW, TRU waste drums, and POCs. Because of the MAR difference and similar container strength of LLW and TRU waste drums, the TRU waste drums bound any release from LLW drums. Although the amount of MAR packaged in a metal box/SWB is more than that packaged in a 55-gallon drum (320 grams versus 200 grams), the 55-gallon drum is assumed to be the container type impacted in this scenario because (1) the amount of MAR per unit volume is greater for TRU drums than for TRU boxes/SWBs, (2) TRU waste is predominantly packaged in 55-gallon drums, and (3) the DBE impacts a large number of containers. In addition, the radiological material inventory is assumed to be TRU waste drums rather than a mixture of POCs and TRU waste containers. This is conservative because POCs are more resistant to breaches than TRU waste containers, and analysis of the POCs indicates that they are not susceptible to breach from falling material unless they are impacted on the side. Since no waste containers are expected to topple, the impact on exposed containers will be on the top of the container.

For BDBE events in substantial construction facilities, 50% of the exposed drums (*i.e.*, drum lids exposed to the ceiling) are assumed to be impacted by falling objects (*e.g.*, overhead equipment, structural supports, lights, etc.) as discussed in Section 8.4.3. For the facility explosion, it is assumed that only 10% of the exposed drums in the facility will be subject to falling objects. This value is based on engineering judgment and is conservative because the facility is not collapsing and the amount of overhead materials available in a facility to fall onto drums is limited. Medium construction facilities have less suspended overhead objects than substantial construction facilities because the main support beams (to which these objects are attached) generally cover about 7% of the facility floor space (Ref. 48). Applying the same reasoning used above, only 1.5% of the exposed drums in medium construction facilities will be subject to the falling debris.

Of the drums subjected to falling objects, it is assumed that 10% of the drums are breached (*i.e.*, penetration of drum and internal packaging). The 10% value is based on engineering judgment and takes into account the strength of the drums (*i.e.*, ***waste container integrity*** control) and the types of overhead materials that may fall (*i.e.*, limited amount of heavy, penetrating overhead objects). Based on these assumptions, the damage ratio is 0.15% (1.5% × 10%) of the exposed drum inventory for medium construction type facilities and 1% (10% × 10%) of the exposed drum inventory (i.e., drum lids exposed to the ceiling) for substantial construction facilities.

Two cases are evaluated: Case A involves a total of 12,000 TRU waste drums in a medium construction facility, and Case B involves a total of 12,000 TRU waste drums in a substantial construction facility. For the purpose of this evaluation, it is assumed that all of the waste drums are stacked four high so that the number of drums stacked on the top tier is one fourth the total number of containers. The number of exposed drums will differ for each facility due to unique stacking arrangements.

Case A: 3,000 exposed TRU drums on upper tier (medium construction facility)

Case B: 3,000 exposed TRU drums on upper tier (substantial construction facility)

The above drum count assumptions are not intended to be restrictions on facility or room inventories or stacking arrangements, but are used only as an estimate to provide an example of how DBE event consequences are determined.

The majority of TRU waste drums at the Site contain less than the 200 grams WG Pu ***container fissile material loading*** limit. Because this scenario is postulated to impact a large number of drums, it is appropriate to use the 95$^{th}$ percentile upper confidence limit (UCL) gram loading value for waste containers at the Site plus some conservatism to account for uncertainty and fluctuations in the Site container gram loading. The 95$^{th}$ percentile UCL for the Site as of June 1998 is 95 grams WG Pu per TRU waste drum (Ref. 49). Adding 20% conservatism, the 95$^{th}$ percentile UCL becomes 114 grams WG Pu per drum, which was used in the evaluation of this scenario. The 95$^{th}$ percentile UCL value will be reviewed on an annual basis and updated as necessary. For purposes of the SES/USQD process, a higher value than the 95$^{th}$ percentile UCL of 95 grams WG Pu but less than the more conservative analyzed value of 114 grams WG Pu will not constitute a reduction in the margin of safety. By using this approach, there is no need for establishing facility MAR limits.

The effective MAR value for this DBE scenario is determined by the following equation:

**Effective MAR = # of exposed drums × facility damage ratio × container MAR**

The effective MAR values for the two facility construction types are shown below. The effective MAR values for both cases are presented in Table 8-21.

Medium construction facilities:

Effective MAR = # of exposed drums × 0.0015 × 114 g WG Pu

Substantial construction facilities:

Effective MAR = # of exposed drums × 0.01 × 114 g WG Pu



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**Table 8-21** Effective MAR Values for NPH Scenario 1

| Case | Number of Top Tier Drums Impacted by Falling Objects | Total MAR (grams WG Pu) [Based on 114 g per container] | Effective MAR (grams WG Pu) | |
|---|---|---|---|---|
| | | | Medium Construction facility (DR = 0.0015) | Substantial Construction facility (DR = 0.01) |
| A | 3,000 | 342,000 | 513 | N/A |
| B | 3,000 | 342,000 | N/A | 3,420 |

A blended DCF of 3.04E+7 is used to conservatively account for the population of waste containers with IDCs that should be modeled with Solubility Class W (Ref. 50).

*Scenario Modeling Assumptions:*

Case A: 3,000 exposed drums, aged WG Pu; 342,000 grams (using a 95th % UCL container loading value); Blended DCF; DR = 0.0015 (medium construction facility).

Case B: 3,000 exposed drums, aged WG Pu; 342,000 grams (using a 95th % UCL container loading value); Blended DCF; DR = 0.01 (substantial construction facility).

Accident Consequence

Case A: The radiological dose consequences of the DBE-induced spill involving 3,000 exposed drums in a medium construction facility are *moderate* (0.12 rem) for the MOI @ 1,200 m, *low* (4.1E-2 rem) for the MOI @ 2,367 m, and *high* (5.6 rem) for the CW. The resulting risk class for the scenario is Risk Class II for the MOI @ 1,200 m (*unlikely* frequency, *moderate* consequences), Risk Class III for the MOI @ 2,367 m (*unlikely* frequency, *low* consequences), and Risk Class I for the CW (*unlikely* frequency, *high* consequences).

Case B: The radiological dose consequences of the DBE-induced spill involving 3,000 exposed drums in a substantial construction facility are *moderate* (0.77 rem) for the MOI @ 1,200 m, *moderate* (0.27 rem) for the MOI @ 2,367 m, and *high* (37 rem) for the CW. The resulting risk class for the scenario is Risk Class II for the MOI @ 1,200 m and 2,367 m (*unlikely* frequency, *moderate* consequences) and Risk Class I for the CW (*unlikely* frequency, *high* consequences).

For the IW located in the vicinity at the time of the event, a DBE event could result in death or serious injury due to falling overhead equipment. There is the potential for the IW to inhale radioactive material being lofted by the spilled containers following the event but the IW would have to remain in the vicinity of the spill. The radiological dose consequences to the IW are qualitatively judged to be *moderate* for both cases due to the amount of radiological material postulated to be released. The ***emergency response*** control is credited for the development of a facility emergency plan directing the IW to evacuate following spills of radioactive materials. The resulting risk class for both cases is Risk Class II to the IW (*unlikely* frequency, *moderate* consequences).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.002 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 1: Case A
3,000 TRU Waste Drums
MOI Distance = 1,200 m
Medium Construction Facility

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 5.13E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 5.13E-02

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 5.6E+00 | 1.2E-01 |
| One | 5.6E-03 | 1.2E-04 |
| Two | 1.1E-05 | 2.3E-07 |
| Three | 2.2E-08 | 4.6E-10 |
| Four | 4.5E-11 | 9.2E-13 |

**NPH Scenario 1 - Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.002 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 1: Case A
3,000 TRU Waste Drums
MOI Distance = 2,367 m
Medium Construction Facility

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 5.13E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 5.13E-02

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 5.6E+00 | 4.1E-02 |
| One | 5.6E-03 | 4.1E-05 |
| Two | 1.1E-05 | 8.2E-08 |
| Three | 2.2E-08 | 1.6E-10 |
| Four | 4.5E-11 | 3.3E-13 |

**NPH Scenario 1 - Case A; Radiological Dose Consequences; 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.010 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 1: Case B
3,000 TRU Waste Drums
MOI Distance = 1,200 m
Substantial Construction Facility
Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 3.42E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.42E-01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 3.7E+01 | 7.7E-01 |
| One | 3.7E-02 | 7.7E-04 |
| Two | 7.4E-05 | 1.5E-06 |
| Three | 1.5E-07 | 3.1E-09 |
| Four | 3.0E-10 | 6.1E-12 |

**NPH Scenario 1 - Case B; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.010 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 1: Case B
3,000 TRU Waste Drums
MOI Distance = 2,367 m
Substantial Construction Facility
Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 3.42E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.42E-01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 3.7E+01 | 2.7E-01 |
| One | 3.7E-02 | 2.7E-04 |
| Two | 7.4E-05 | 5.5E-07 |
| Three | 1.5E-07 | 1.1E-09 |
| Four | 3.0E-10 | 2.2E-12 |

**NPH Scenario 1 - Case B; Radiological Dose Consequences; 2,367 m**



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## Table 8-22 NPH Scenario 1: Case A - DBE-Induced Spill (Medium Construction Facility)

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) and 13H (Other Hazards/Seismic Induced Spills) |
| Accident Type | Seismic event involving 1,500 exposed TRU waste drums; DBE causes falling debris with subsequent drum breaches<br>Effective MAR = 256.5 grams of aged WG Pu (0.15% damage ratio, 95th % UCL Container MAR); occurs in any of the medium construction facilities |
| Cause or Energy Source | [causes] 13H (Seismic Induced Spills)<br>[energy sources] falling overhead equipment |
| Applicable Activity(ies) | SH |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Unlikely | Not Applicable | @ 1,200 m<br>Moderate<br>0.12 rem<br>@ 2,367 m<br>Low<br>4.1E-2 rem | Not Applicable | @ 1,200 m<br>II<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Container Stacking (Banding)<br>Building Structure | C<br>C<br>C<br>C | M<br>M<br>P<br>M | AOL 1<br>AOL 4<br>AOL 6<br>AC 5.4 |
| CW | Unlikely | Unlikely | Not Applicable | High<br>5.6 rem | Not Applicable | I | Same as MOI | | | |
| IW | Unlikely | Unlikely | Moderate | Moderate | Not Applicable | II | Container Integrity<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>D<br>D<br>D | M<br>M<br>M<br>M<br>M | AOL 1<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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# Table 8-23 NPH Scenario 1: Case B - DBE-Induced Spill (Substantial Construction Facility)

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) and 13H (Other Hazards/Seismic Induced Spills) |
| Accident Type | Seismic event involving 1,500 exposed TRU waste drums; DBE causes falling debris with subsequent drum breaches<br>Effective MAR = 256.5 grams of aged WG Pu (0.15% damage ratio, 95th % UCL Container MAR); occurs in any of the substantial construction facilities |
| Cause or Energy Source | causes] 13H (Seismic Induced Spills)<br>[energy sources] falling overhead equipment |
| Applicable Activity(ies) | SH |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation. | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Unlikely | Not Applicable | @ 1,200 m<br>Moderate<br>0.77 rem<br>@ 2,367 m<br>Moderate<br>0.27 rem | Not Applicable | @ 1,200 m<br>II<br>@ 2,367 m<br>II | Container Integrity<br>Container Fissile Material Loading<br>Container Stacking (Banding)<br>Building Structure | C<br>C<br>C<br>C | M<br>M<br>P<br>M | AOL 1<br>AOL 4<br>AOL 6<br>AC 5.4 |
| CW | Unlikely | Unlikely | Not Applicable | High<br>37 rem | Not Applicable | I | Same as MOI | | | |
| IW | Unlikely | Unlikely | High | Moderate | Not Applicable | II | Container Integrity<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>D<br>D<br>D | M<br>M<br>M<br>M<br>M | AOL 1<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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### 8.4.3 NPH Scenario 2 - BDBE Event-Induced Spill

The BDBE accident scenario is discussed below and is summarized in Tables 8-28 through 8-30. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text.

Accident Scenario

A BDBE is postulated to occur impacting the waste storage areas of light, medium and substantial construction facilities. By definition, structural collapse is expected in a BDBE event. Containers may be breached by falling objects (*e.g.*, equipment and structure) from the partial collapse of the facility or may topple and fall from upper tier stacks (third or fourth tiers). The containers that are breached from falling debris will not spill their contents because the breach is at the top or upper portion of the container. Since radioactive material will not be "flowing" from the containers, as is the case in the forklift tine puncture of containers (see Spill Scenario 2, *Waste Container Puncture by Forklift Tine*), these container breaches are analyzed as confined material releases as are the TRU waste container breaches due to toppling and falling.

The spill is a short duration event and a minimum duration release (10 minutes) is analyzed. A ground-level (non-lofted) release of the radioactive material is assumed. A concurrent fire, caused by the earthquake, is not considered due to the low combustible loading in the waste storage areas as required by the ***fuel/combustible loading and ignition source control*** program.

Three cases are evaluated for this scenario. Case A involves the LLW inventory of a light construction facility (or open storage area) in which waste containers, stacked on third and fourth tiers, are breached as they fall during the BDBE event. The falling structural supports of a light construction facility (*e.g.*, waste storage tent) will not cause a container breach by direct impact due to insufficient mass of the supports. Case B and Case C involve the TRU waste inventory of a medium and substantial construction facility, respectively, in which exposed drums (*e.g.*, those located on the top tier) are impacted by falling structural supports, equipment and debris. Case B and Case C also postulate container breaches due to toppling and falling.

*Scenario Modeling Assumptions*: spill; confined material; 10 minute duration.

Accident Frequency

The likelihood of this postulated accident scenario is judged to be *unlikely* based upon seismic history of the region (Ref. 2). A concurrent fire with the BDBE is considered *beyond extremely unlikely* due to the credited ***fuel/combustible loading and ignition source control*** program that limits the amount of combustibles in waste storage areas.

*Scenario Modeling Assumptions*: *unlikely* event.



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Material-At-Risk

Waste containers are impacted by the BDBE event in two ways: (1) partial collapse of the facility creates significant debris that can fall onto exposed containers; and (2) third or fourth tier waste drums may topple and fall (drop more than four feet).

The MAR values associated with the container types evaluated in the seismic scenarios are presented in Table 8-20. These MAR values are used to determine the bounding container types for the representative seismic scenarios. There is no source of heavy falling debris in light construction facilities or open storage areas where LLW is stored. Therefore, a BDBE event affecting a light construction facility or open storage area is postulated to involve only LLW containers that topple and fall. Even though the amount of MAR contained in a LLW box is more than a 55-gallon drum (3 grams versus 0.5 grams), the 55-gallon drum is assumed to be the container type impacted in this scenario because LLW waste is predominantly packaged in 55-gallon drums and the BDBE impacts a large number of containers.

There are no medium or substantial construction facilities that store only LLW, therefore a BDBE event affecting medium or substantial construction facilities is assumed to involve a combination of LLW, TRU waste, and POCs. Because of the MAR difference and similar container strength of LLW and TRU waste drums, the TRU waste drums bound any release from LLW drums. Although the amount of MAR packaged in a metal box/SWB is more than that packaged in a 55-gallon drum (320 grams versus 200 grams), the 55-gallon drum is assumed to be the container type impacted in this scenario because (1) the amount of MAR per unit volume is greater for TRU drums than for TRU boxes/SWBs, (2) TRU waste is predominantly packaged in 55-gallon drums, and (3) the BDBE impacts a large number of containers. In addition, the radiological material inventory is assumed to be TRU waste drums rather than a mixture of POCs and TRU waste containers. This is conservative because: (1) POCs are more resistant to breaches than TRU waste containers and are not susceptible to falls due to toppling (eliminates MAR associated with containers falling from upper tiers of stacks) resulting in a DR of 10% versus 100% for TRU waste containers (Ref. 34); (2) releases from both containers would have the same ARF value (*i.e.*, confined material spill, ARF = 0.001); and (3) even though POCs have a greater maximum MAR than TRU waste drums (1,255 g WG Pu equivalent versus 200 grams WG Pu), POCs have an RF value that is an order of magnitude lower than the RF for TRU waste containers (*i.e.*, POC RF = 0.01, TRU waste container RF = 0.1). Combining the above considerations, the POC has a lower initial respirable source term (IRST) for the seismic event release than does the TRU waste container as shown:

$$IRST = MAR \times DR \times ARF \times RF$$

$$IRST_{POC} = 1{,}255 \times 0.1 \times 0.001 \times 0.01 = 1.25E\text{-}3$$

$$IRST_{TRU\ Drum} = 200 \times 1.0 \times 0.001 \times 0.1 = 2E\text{-}2$$

Therefore, the analysis of the BDBE considers only TRU waste drums.

For substantial construction facilities, 50% of the exposed drums (i.e., drum lids exposed to the ceiling) are assumed to be impacted by falling debris (overhead equipment and structural supports). Medium construction facilities have less suspended overhead objects than heavy construction facilities because the main support beams (to which these objects are attached) generally cover about 7% of the facility floor space in a grid arrangement. It is therefore assumed



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that 7% of the exposed drums in medium construction facilities would be subject to falling debris. Of the drums subjected to falling debris, it is assumed that 10% of the drums are breached (*i.e.*, penetration of drum and internal packaging). The 10% value is based on engineering judgment and takes into account the strength of the drums (*i.e.*, ***waste container integrity*** control) and the types of overhead materials that may fall (*i.e.*, limited amount of heavy, penetrating overhead materials). Based on these assumptions, the damage ratio is 0.7% for the exposed drum inventory in medium construction facilities, and 5% for the exposed drum inventory (*i.e.*, drum lids exposed to the ceiling) in substantial construction facilities.

Another contributing factor to the damage caused by the BDBE event is stacked waste drums toppling and falling from the upper tiers. It is conservatively assumed that 25% of the drums stacked on the third and fourth tiers will topple and fall during a BDBE event. The 25% value is based on engineering judgment and is believed to be conservative since: (1) stacked drums are not susceptible to toppling except for very large seismic events; and (2) the credited ***container stacking (banding)*** control reduces the likelihood of drums toppling from upper tiers of stacks. Of the drums subjected to toppling from upper tiers, it is assumed that 25% of these drums are breached (*i.e.*, failure of drum and internal packaging). This 25% value is also based on engineering judgment and takes into account the strength of the drums (*i.e.*, ***container integrity*** control), the ***container stacking (banding)*** control (a single drum in the four banded set is subject to damage from the crushing weight of the other three drums in the banded set), and the limited amount of room available for upper tier drums to fall onto the floor (*i.e.*, other drums in the way or limited aisle space). Additional strength or resistance to internal package breaching as a result of toppling is provided by rigid liners and/or at least one polyurethane bag. Drums that are compliant with internal packaging requirements have these barriers. Non-compliant drums are more susceptible to internal package breach as a result of drum falling. It is assumed that 20% of the compliant breached drums, as a result of falling, will have breaches of the internal packaging. It is conservatively assumed that 100% of the non-compliant breached drums will have a breach in the internal packaging. It is conservatively assumed that 85% of drums on the Site are compliant with internal packaging requirements (based on Real Time Radiography, RTR, statistics that over 86% were compliant (Ref. 51)) leaving 15% that are not compliant.

Two damage ratios are calculated for the toppled and failed drums: one for drums with compliant inner packaging and a second for drums with non-compliant inner packaging. Both damage ratios assume that 25% of the upper tier drums topple, and that 25% of the toppled drums fail due to the impact with the ground. Of the toppled and failed drums, those with compliant inner packaging (85%) have a damage ratio of 20% (*e.g.*, only 20% of the drums have damaged packaging) and those with non-compliant inner packaging (15%) have a damage ratio of 100% (*e.g.*, all of the drums have deficient or damaged packaging). Based on these assumptions, the damage ratio due to toppling and falling from the third and fourth tiers is represented by the following equation:

$$DR_{Fall} = \text{\# of } 3^{rd} \text{ and } 4^{th} \text{ tier drums} \times 25\% \times 25\% \times [(85\% \times 20\%) + (15\% \times 100\%)]$$

The simplified equation becomes:

$$DR_{Fall} = \text{\# of } 3^{rd} \text{ and } 4^{th} \text{ tier drums} \times 2\%$$



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The majority of TRU waste drums at the Site contain less than the 200 grams WG Pu ***container fissile material loading*** limit. Because this scenario is postulated to impact a large number of drums, it is appropriate to use the 95th percentile upper confidence limit (UCL) gram loading value for waste containers at the Site plus some conservatism to account for uncertainty and fluctuations in the Site container gram loading. The 95th percentile UCL for the Site as of June 1998 is 95 grams WG Pu per TRU waste drum (Ref. 49). Adding 20% conservatism, the 95th percentile UCL becomes 114 grams WG Pu per drum, which was used in the evaluation of this scenario. The 95th percentile UCL value will be reviewed on an annual basis and updated as necessary. For purposes of the SES/USQD process, a higher value than the 95th percentile UCL of 95 grams WG Pu but less than the more conservative analyzed value of 114 grams WG Pu will not constitute a reduction in the margin of safety. By using this approach, there is no need for establishing facility MAR limits.

The effective MAR for a scenario is determined by the following calculation:

**Effective MAR = a + b**

where

*a = MAR from exposed drums (top tier) being breached by falling debris*
*b = MAR from falling 3rd and 4th tier drums*

Further defining these parameters:

*a = # of exposed drums × facility DR* x *container MAR*
*b = # of 3rd and 4th tier drums × falling drum DR × container MAR*

Light construction facilities (or open storage areas):

a = (not applicable, DR = 0)
b = # of 3rd and 4th tier drums × 0.02 × 0.24 g WG Pu

Medium construction facilities:

a = # of exposed drums × 0.007 × 114 g WG Pu
b = # of 3rd and 4th tier drums × 0.02 × 114 g WG Pu

Substantial construction facilities:

a = # of exposed drums × 0.05 × 114 g WG Pu
b = # of 3rd and 4th tier drums × 0.02 × 114 g WG Pu

Note that the facility damage ratio (in "a") is the only difference between facility type effective MAR calculation parameters. The damage ratio associated with falling drums is the same for each of the facility types. For the purposes of this evaluation, it is assumed that all of



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the waste drums are stacked four high so that the number of drums stacked on the top tier is one fourth of the total number of containers. Similarly, the number of drums stacked on the third and fourth tiers is one half of the total number of containers.

Three cases are evaluated: Case A involves a total of 12,000 LLW drums in a light construction facility, Case B involves a total of 12,000 TRU waste drums in a medium construction facility, and Case C involves a total of 12,000 TRU waste drums in a substantial construction facility.

Case A: 6,000 LLW drums on 3rd and 4th tier
(light construction facility, therefore no impact from falling debris)

Case B: 3,000 exposed TRU drums on upper tier, 6,000 TRU drums on 3rd and 4th tier
(medium construction facility)

Case C: 3,000 exposed TRU drums on upper tier, 6,000 TRU drums on 3rd and 4th tier (substantial construction facility)

The above drum count assumptions are not intended to be restrictions on facility or room inventories or stacking arrangements, but are used only to provide an example of how BDBE consequences are determined. The number of exposed drums and drums stacked on the 3rd and 4th tiers will differ for each facility due to unique stacking arrangements. The effective MAR for the three cases is presented in Table 8-24. A blended DCF is used to conservatively account for the population of waste containers with IDCs that should be modeled with Solubility Class W. For LLW waste, 3.07E+7 is used; for TRU waste, 3.04E+7 is used.

*Scenario Modeling Assumptions:*

Case A: 3,000 drums on 3rd and 4th tiers; 1,440 grams; aged WG Pu; Blended DCF; DR = 0.02.

Case B: 3,000 exposed drums = 342,000 grams (using a 95th % UCL container loading value); 6,000 drums on 3rd and 4th tiers = 684,000 grams (using a 95th % UCL container loading value); aged WG Pu; Blended DCF; Exposed Drum DR = 0.007 (medium construction facility), 3rd&4th Tier Drum DR = 0.02.

Case C: 3,000 exposed drums = 342,000 grams (using a 95th % UCL container loading value); 6,000 drums on 3rd and 4th tiers = 684,000 grams (using a 95th % UCL container loading value); aged WG Pu; Blended DCF; Exposed Drum DR = 0.05 (substantial construction facility), 3rd&4th Tier Drum DR = 0.02.

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**Table 8-24** Effective MAR for NPH Scenario 2

| Case | Number of Top Tier Drums Exposed to Falling Debris | Available MAR from Drums Breached by Falling Debris (grams WG Pu) [Based on 114 g per TRU drum] | Effective MAR from Drums Breached by Falling Debris | | Number of 3rd and 4th Tier Drums | Available MAR from Falling Drums [Based on 114 g per TRU drum and 0.24 g per LLW box] | Effective MAR from Falling Drums (DR = 0.02) | Total Effective MAR (grams WG Pu) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Medium Construction facility (DR = 0.007) | Substantial Construction facility (DR = 0.05) | | | | Light Construction facility (or Open Storage Area) | Medium Construction facility | Substantial Construction facility |
| A | N/A | N/A | N/A | N/A | 6,000 | 1,440 | 28.8 | 28.8 | N/A | N/A |
| B | 3,000 | 342,000 | 2,394 | NA | 6,000 | 684,000 | 13,680 | N/A | 16,074 | N/A |
| C | 3,000 | 342,000 | N/A | 17,100 | 6,000 | 684,000 | 13,680 | N/A | N/A | 30,780 |

Accident Consequences

The radiological consequences for each case are presented in a summary table because the consequences have two additive components.

**Table 8-25** NPH Scenario 2 – Case A; Radiological Dose Consequence Summary

| Dose Component | Effective MAR (grams WG Pu Equivalent) | Collocated Worker Dose (rem) | MOI Dose (rem) | |
|---|---|---|---|---|
| | | 100 m | 1,200 m | 2,367 m |
| Exposed Drums Breached (e.g., top tier) | 0 | 0 | 0 | 0 |
| Stacked Drums Fall/Breach ($3^{rd}$ and $4^{th}$ Tier) | 28.8 | 0.32 | 6.5E-3 | 2.3E-3 |
| Totals | 28.8 | 0.32 | 6.5E-3 | 2.3E-3 |

Case A: The radiological dose consequences of the BDBE-induced spill involving 6,000 LLW drums stacked on the $3^{rd}$ and $4^{th}$ tier in a light construction facility are *low* (6.5E-3 rem) for the MOI @ 1,200 m, *low* (2.3E-3 rem) for the MOI @ 2,367 m, and *low* (0.32 rem) for the CW. The resulting risk class for the scenario is Risk Class III for the MOI @ 1,200 m and 2,367 m (*unlikely* frequency, *low* consequence) and Risk Class III for the CW (*unlikely* frequency, *low* consequence).

**Table 8-26** NPH Scenario 2 – Case B; Radiological Dose Consequence Summary

| Dose Component | Effective MAR (grams WG Pu Equivalent) | Collocated Worker Dose (rem) | MOI Dose (rem) | |
|---|---|---|---|---|
| | | 100 m | 1,200 m | 2,367 m |
| Exposed Drums Breached (e.g., top tier) | 2,394 | 26 | 0.54 | 0.19 |
| Stacked Drums Fall/Breach ($3^{rd}$ and $4^{th}$ Tier) | 13,680 | 150 | 3.1 | 1.1 |
| Totals | 16,074 | 176 | 3.6 | 1.3 |

Case B: The radiological dose consequences of the BDBE-induced spill involving 3,000 exposed (top tier) TRU drums and 6,000 TRU drums stacked on the $3^{rd}$ and $4^{th}$ tier in a medium construction facility are *moderate* (3.6 rem) for the MOI @ 1,200 m, *moderate* (1.3 rem) for the MOI @ 2,367 m, and *high* (153 rem) for the CW. The resulting risk class for the scenario is Risk Class II for the MOI @ 1,200 m and 2,367 m (*unlikely* frequency, *moderate* consequence) and Risk Class I for the CW (*unlikely* frequency, *high* consequence).

**Table 8-27** NPH Scenario 2 – Case C; Radiological Dose Consequence Summary

| Dose Component | Effective MAR (grams WG Pu Equivalent) | Collocated Worker Dose (rem) | MOI Dose (rem) | |
|---|---|---|---|---|
| | | 100 m | 1,200 m | 2,367 m |
| Exposed Drums Breached (e.g., top tier) | 17,100 | 190 | 3.8 | 1.4 |
| Stacked Drums Fall/Breach (3rd and 4th Tier) | 13,680 | 150 | 3.1 | 1.1 |
| Totals | 30,780 | 340 | 6.9 | 2.5 |

Case C: The radiological dose consequences of the BDBE-induced spill involving 3,000 exposed drums in a substantial construction facility are *high* (6.9 rem) for the MOI @ 1,200 m, *moderate* (2.5 rem) for the MOI @ 2,367 m, and *high* (340 rem) for the CW. The resulting risk class for the scenario is Risk Class I for the MOI @ 1,200 m (*unlikely* frequency, *high* consequence), Risk Class II for the MOI @ 2,367 m, (*unlikely* frequency, *moderate* consequence), and Risk Class I for the CW (*unlikely* frequency, *high* consequence).

For the IW located in a light construction facility or open storage area (Case A) at the time of the earthquake, death or serious injury could result from falling waste containers and overhead equipment. There is the potential for the IW to inhale radioactive material being lofted by the spilled containers following the event, but the IW would have to remain in the vicinity of the spill. The radiological dose consequences to the IW are qualitatively judged to be *moderate* due to the amount of radiological material postulated to be released. The ***emergency response*** control is credited for the development of a facility emergency plan directing the IW to evacuate following spills of radioactive materials. The resulting risk class for both cases is Risk Class II to the IW (*unlikely* frequency, *moderate* consequences).

For the IW located in a medium or substantial construction facility (Case B and Case C) at the time of the earthquake, partial facility collapse could result in a fatality (*high* consequences). No controls are credited for protecting the IW in this scenario since the impacts of the initiating event are so severe that radiological impacts are of little consequence. The ***emergency response*** control is credited for the development of a facility emergency plan directing the IW to evacuate following spills of radioactive materials. However, the resulting risk class for the BDBE scenario is Risk Class I for the IW (*unlikely* frequency, *high* consequence). This *high* consequence is due to the increased radiological exposure in the case where an IW is trapped in the rubble.

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.020 | |
| Material at Risk (g) = | 1.44E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case A
LLW Waste Drums: 6,000 stacked at 3rd and 4th tier
MOI Distance = 1,200 m
Light Construction Facility or Open Storage Area

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.07E+07 | 3.07E+07 |
| Effective MAR, Including DR (g) = | 2.88E+01 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 2.88E-03

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 3.2E-01 | 6.5E-03 |
| One | 3.2E-04 | 6.5E-06 |
| Two | 6.3E-07 | 1.3E-08 |
| Three | 1.3E-09 | 2.6E-11 |
| Four | 2.5E-12 | 5.2E-14 |

**NPH Scenario 2 - Case A; Radiological Dose Consequences; 1,200 m (Light Construction Facility – Falling Drum Stacks)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.020 | |
| Material at Risk (g) = | 1.44E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case A
LLW Waste Drums: 6,000 stacked at 3rd and 4th tier
MOI Distance = 2,367 m
Light Construction Facility or Open Storage Area

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.07E+07 | 3.07E+07 |
| Effective MAR, Including DR (g) = | 2.88E+01 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 2.88E-03

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 3.2E-01 | 2.3E-03 |
| One | 3.2E-04 | 2.3E-06 |
| Two | 6.3E-07 | 4.6E-09 |
| Three | 1.3E-09 | 9.3E-12 |
| Four | 2.5E-12 | 1.9E-14 |

**NPH Scenario 2 - Case A; Radiological Dose Consequences; 2,367 m (Light Construction Facility – Falling Drum Stacks)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.007 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case B
TRU Waste Drums: 3,000 exposed (e.g., top tier)
MOI Distance = 1,200 m
Medium Construction Facility

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 2.39E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.6E+01 | 5.4E-01 |
| One | 2.6E-02 | 5.4E-04 |
| Two | 5.2E-05 | 1.1E-06 |
| Three | 1.0E-07 | 2.2E-09 |
| Four | 2.1E-10 | 4.3E-12 |

Respirable Initial Source Term (g) = 2.39E-01

**NPH Scenario 2 - Case B; Radiological Dose Consequences; 1,200 m (Medium Construction Facility – Exposed Drums)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.007 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case B
TRU Waste Drums: 3,000 exposed (e.g., top tier)
MOI Distance = 2,367 m
Medium Construction Facility

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 2.39E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.6E+01 | 1.9E-01 |
| One | 2.6E-02 | 1.9E-04 |
| Two | 5.2E-05 | 3.8E-07 |
| Three | 1.0E-07 | 7.6E-10 |
| Four | 2.1E-10 | 1.5E-12 |

Respirable Initial Source Term (g) = 2.39E-01

**NPH Scenario 2 - Case B; Radiological Dose Consequences; 2,367 m (Medium Construction Facility – Exposed Drums)**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.020 | |
| Material at Risk (g) = | 6.84E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case B
TRU Waste Drums: 6,000 stacked at 3rd and 4th tier
MOI Distance = 1,200 m
Medium Construction Facility
Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 1.37E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.37E+00

RESULTS

| Number of HEPA Stages | CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 1.5E+02 | 3.1E+00 |
| One | 1.5E-01 | 3.1E-03 |
| Two | 3.0E-04 | 6.1E-06 |
| Three | 6.0E-07 | 1.2E-08 |
| Four | 1.2E-09 | 2.5E-11 |

**NPH Scenario 2 - Case B; Radiological Dose Consequences; 1,200 m (Medium Construction Facility – Falling Drum Stacks)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.020 | |
| Material at Risk (g) = | 6.84E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case B
TRU Waste Drums: 6,000 stacked at 3rd and 4th tier
MOI Distance = 2,367 m
Medium Construction Facility
Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 1.37E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.37E+00

RESULTS

| Number of HEPA Stages | CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 1.5E+02 | 1.1E+00 |
| One | 1.5E-01 | 1.1E-03 |
| Two | 3.0E-04 | 2.2E-06 |
| Three | 6.0E-07 | 4.4E-09 |
| Four | 1.2E-09 | 8.7E-12 |

**NPH Scenario 2 - Case B; Radiological Dose Consequences; 2,367 m (Medium Construction Facility – Falling Drum Stacks)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.050 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

NPH Scenario 2: Case C
TRU Waste Drums: 3,000 exposed (e.g., top tier)
MOI Distance = 1,200 m
Substantial Construction Facility

Version 1.2

| Default Parameters | | Change Options: Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 1.71E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses: CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 1.9E+02 | 3.8E+00 |
| One | 1.9E-01 | 3.8E-03 |
| Two | 3.7E-04 | 7.7E-06 |
| Three | 7.4E-07 | 1.5E-08 |
| Four | 1.5E-09 | 3.1E-11 |

Respirable Initial Source Term (g) = 1.71E+00

**NPH Scenario 2 - Case C; Radiological Dose Consequences; 1,200 m (Substantial Construction Facility – Exposed Drums)**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.050 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

NPH Scenario 2: Case C
TRU Waste Drums: 3,000 exposed (e.g., top tier)
MOI Distance = 2,367 m
Substantial Construction Facility

Version 1.2

| Default Parameters | | Change Options: Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 1.71E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses: CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 1.9E+02 | 1.4E+00 |
| One | 1.9E-01 | 1.4E-03 |
| Two | 3.7E-04 | 2.7E-06 |
| Three | 7.4E-07 | 5.5E-09 |
| Four | 1.5E-09 | 1.1E-11 |

Respirable Initial Source Term (g) = 1.71E+00

**NPH Scenario 2 - Case C; Radiological Dose Consequences; 2,367 m (Substantial Construction Facility – Exposed Drums)**



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# Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.020 | |
| Material at Risk (g) = | 6.84E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case C
TRU Waste Drums: 6,000 stacked at 3rd and 4th tier
MOI Distance = 1,200 m
Substantial Construction Facility

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 1.37E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.37E+00

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 1.5E+02 | 3.1E+00 |
| One | 1.5E-01 | 3.1E-03 |
| Two | 3.0E-04 | 6.1E-06 |
| Three | 6.0E-07 | 1.2E-08 |
| Four | 1.2E-09 | 2.5E-11 |

**NPH Scenario 2 - Case C; Radiological Dose Consequences; 1,200 m (Substantial Construction Facility – Falling Drum Stacks )**

# Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.020 | |
| Material at Risk (g) = | 6.84E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
NPH Scenario 2: Case C
TRU Waste Drums: 6,000 stacked at 3rd and 4th tier
MOI Distance = 2,367 m
Substantial Construction Facility

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 1.37E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.37E+00

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 1.5E+02 | 1.1E+00 |
| One | 1.5E-01 | 1.1E-03 |
| Two | 3.0E-04 | 2.2E-06 |
| Three | 6.0E-07 | 4.4E-09 |
| Four | 1.2E-09 | 8.7E-12 |

**NPH Scenario 2 - Case C; Radiological Dose Consequences; 2,367 m (Substantial Construction Facility – Falling Drum Stacks)**



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## Table 8-28 NPH Scenario 2: Case A - BDBE-Induced Spill (Light Construction Facility)

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container) and 13H (Other Hazards/Seismic Induced Spills) |
| **Accident Type** | Seismic event involving 6,000 LLW waste drums stacked on 3rd and 4th tiers; BDBE causes stacked waste drums to fall<br>Effective MAR = 28.8 grams of aged WG Pu (2% damage ratio, 95th % UCL Container MAR); occurs in any of the light construction facilities or open storage areas |
| **Cause or Energy Source** | [causes] 13H (Seismic Induced Spills)<br>[energy sources] 8C (Stacked Waste Containers) |
| **Applicable Activity(ies)** | SH |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Unlikely | Not Applicable | @ 1,200 m<br>Low<br>6.5E-3 rem<br>@ 2,367 m<br>Low<br>2.3E-3 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Container Integrity<br>Container Fissile Material Loading<br>Container Stacking (Banding) | C<br>C<br>C | M<br>M<br>P | AOL 1<br>AOL 4<br>AOL 6 |
| CW | Unlikely | Unlikely | Not Applicable | Low<br>0.32 rem | Not Applicable | III | Same as MOI | | | |
| IW | Unlikely | Unlikely | Not Applicable | Low | Not Applicable | III | Container Integrity<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>D<br>D<br>D | M<br>M<br>M<br>M<br>M | AOL 1<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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**Table 8-29** NPH Scenario 2: Case B - BDBE-Induced Spill (Medium Construction Facility)

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container) and 13H (Other Hazards/Seismic Induced Spills) |
| **Accident Type** | Seismic event involving TRU waste drums: 3,000 exposed (top tier); 6,000 on 3rd and 4th tiers; DBE causes facility structural failure and toppling stacks of drums<br>Effective MAR = 16,074 grams of aged WG Pu (0.7% DR for exposed drums, 2% DR for stacked drums, 95th % UCL Container MAR); occurs in any of the medium construction facilities |
| **Cause or Energy Source** | [causes] 13H (Seismic Induced Spills)<br>[energy sources] 8C (Stacked Waste Containers) and falling structure/equipment/debris |
| **Applicable Activity(ies)** | SH |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Unlikely | Not Applicable | @ 1,200 m<br>Moderate 3.6 rem<br>@ 2,367 m<br>Moderate 1.3 rem | Not Applicable | @ 1,200 m<br>II<br>@ 2,367 m<br>II | Container Integrity<br>Container Fissile Material Loading<br>Container Stacking (Banding)<br>Building Structure | C<br>C<br>C<br>C | M<br>M<br>P<br>P/M | AOL 1<br>AOL 4<br>AOL 6<br>AC 5.4 |
| CW | Unlikely | Unlikely | Not Applicable | High 176 rem | Not Applicable | I | Same as MOI | | | |
| IW | Unlikely | Unlikely | Not Applicable | Moderate | Not Applicable | II | Container Integrity<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>D<br>D<br>D | M<br>M<br>M<br>M<br>M | AOL 1<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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**Table 8-30** NPH Scenario 2: Case C - BDBE-Induced Spill (Substantial Construction Facility)

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container) and 13H (Other Hazards/Seismic Induced Spills) |
| **Accident Type** | Seismic event involving TRU waste drums: 3,000 exposed (top tier); 6,000 on 3rd and 4th tiers; DBE causes facility structural failure and toppling stacks of drums<br>Effective MAR = 30,780 grams of aged WG Pu (5% DR for exposed drums, 2% DR for stacked drums, 95th % UCL Container MAR); occurs in any of the substantial construction facilities |
| **Cause or Energy Source** | causes] 13H (Seismic Induced Spills)<br>[energy sources] 8C (Stacked Waste Containers) and falling structure/equipment/debris |
| **Applicable Activity(ies)** | SH |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Unlikely | Unlikely | Not Applicable | @ 1,200 m<br>High<br>6.9 rem<br>@ 2,367 m<br>Moderate<br>2.5 rem | Not Applicable | @ 1,200 m<br>I<br>@ 2,367 m<br>II | Container Integrity<br>Container Fissile Material Loading<br>Container Stacking (Banding)<br>Building Structure | C<br>C<br>C<br>C | M<br>M<br>P<br>P/M | AOL 1<br>AOL 4<br>AOL 6<br>AC 5.4 |
| CW | Unlikely | Unlikely | Not Applicable | High<br>340 rem | Not Applicable | I | Same as MOI | | | |
| IW | Unlikely | Unlikely | Not Applicable | High | Not Applicable | I | Container Integrity<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>D<br>D<br>D | M<br>M<br>M<br>M<br>M | AOL 1<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

### 8.4.4 Control Set Vulnerability

The postulated DBE and BDBE have *unlikely* scenario frequency bin assignments. Concurrent failures of mitigative features would lead to an *extremely unlikely* frequency bin assignment for the scenario. Slight increases in MAR due to protective feature failures would have no impact on the direct earthquake consequences and would contribute little in increasing any radiological consequences associated with the event due to the amount of material released.

Failure of the ***fuel/combustible loading and ignition source control*** program could result in a fire concurrent with the DBE or BDBE event. If the fire were of significant size, the release fraction assumed in the analysis would significantly increase (*i.e.*, breached drums could have a combined airborne release fraction and respirable fraction of up to 0.05 rather than the 0.0001 used in the analysis). Failure of this protective feature could yield significant consequences. However, the likelihood of failing the ***fuel/combustible loading and ignition source control*** program, having a DBE or BDBE, and having an ignition source in the area of the excess combustible materials is considered *beyond extremely unlikely*.

Failure of the ***container fissile material loading*** mitigative feature (higher MAR containers) would result in additional MAR and a corresponding increase in the radiological dose consequences.

Failure of either the ***container integrity*** or ***container stacking (banding)*** protective features could lead to more drums being breached and result in additional MAR and a corresponding increase in the radiological dose consequences..

In all situations discussed above, the following defense-in-depth feature tends to mitigate the scenario but is not credited in the analysis:

- Building Structure: The building structure design feature (an attribute of the ***Maintenance and Surveillance of SC-3 SSCs***) can lead to mitigating the effects of the DBE (remaining intact yielding an ambient leakpath factor). The building structure design feature can lead to the preventing (reducing the likelihood of building partial collapse) and mitigating the effects of the BDBE (remaining intact yielding an ambient leakpath factor and reducing the number of drums impacted by falling debris, allowing the IW to survive the event and evacuate the facility).
- ***Fuel/combustible loading and ignition source control***, ***container integrity***, and ***container fissile material loading***: The ***fuel/combustible loading and ignition source control*** program, the ***container integrity*** feature, and the ***container fissile material loading*** limits all reduce the radiological source term that the IW could be exposed to following the DBE.
- ***Training*** (IW only): The IW ***training*** program is an additional mitigative feature that can reduce IW consequences as a reinforcement of ***emergency response*** evacuation guidance.
- ***Emergency Response***: ***Emergency Response*** directs the IW to evacuate the facility in the event of spills of radioactive material that lessens the worker exposure to radiological material releases.
- ***LS/DW*** (IW only): Facility management or other personnel can utilize the ***LS/DW system*** to reduce IW consequences by announcing the spill to facility personnel.



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### 8.4.5 NPH Scenario Assumptions

In the evaluation of the NPH scenarios, assumptions are identified for prevention and/or mitigation of the accidents. Table 8-31 presents a listing of the assumptions specified in the evaluation of NPH scenarios. The scenarios/cases to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 8-31** NPH Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| LLW Containers contain no more than 0.5 grams WG PU equivalent in drums and 3 grams WG PU equivalent in metal boxes. | NPH Scenario 2, Case A | Sets the MAR for determining the bounding LLW container type postulated for the seismic-induced spill scenario.<br>***Container Fissile Material Loading*** |
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs. | NPH Scenario 1<br>NPH Scenario 2, Case B<br>NPH Scenario 2, Case C | Sets the MAR for determining the bounding TRU waste container type postulated for the seismic-induced spill scenario.<br>***Container Fissile Material Loading*** |
| The 95th percentile UCL gram loading value for LLW drums is appropriate for seismic events. | NPH Scenario 2, Case A | Sets the total LLW MAR for the seismic-induced spill scenario. |
| The 95th percentile UCL gram loading value for TRU drums is appropriate for seismic events. | NPH Scenario 1<br>NPH Scenario 2, Case B<br>NPH Scenario 2, Case C | Sets the total TRU waste MAR for the seismic-induced spill scenario. |
| A drop/fall of banded waste drums results in the equivalent release of material of one waste drum. | NPH Scenario 2 | Sets the potential MAR for the scenario impacting TRU or low-level waste containers.<br>***Container Stacking (Banding)*** |
| Waste containers stacked above the second tier will be banded. | NPH Scenario 2 | Reduces the effective MAR of the scenario due to a pallet of waste drums dropping or falling from the third or fourth tier of the stack.<br>***Container Stacking (Banding)*** |
| It is *beyond extremely unlikely* to breach a POC or Type B shipping container by structural member or falling object impacts due to impact angle requirements and weight needed to lead to failure. | NPH Scenario 1<br>NPH Scenario 2 | Reduces the likelihood of POC or Type B shipping container failure from impacts with structural members or falling objects by two frequency bins.<br>***Container Integrity (POC/Type B Container)*** |
| Metal waste containers cannot be breached by falls less than four feet. | NPH Scenario 2 | Reduces the likelihood of TRU and low-level waste container failure due to dropping from less than four feet to *Beyond Extremely Unlikely.*<br>***Container Integrity*** |



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**Table 8-31** NPH Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| A combustible material and ignition source control program shall be implemented to make fires in areas containing staged or stored radioactive material *unlikely* events.<br>Elements of combustible material control include:<br>• high heat release rate combustible material restrictions;<br>• no wooden crates in internal waste storage areas;<br>• combustibles have five foot separation from waste containers.<br>Elements of ignition source control include:<br>• restrictions on smoking in facilities;<br>• hot work permits. | NPH Scenario 1<br>NPH Scenario 2 | Reduces the likelihood of seismic-induced fires to *Beyond Extremely Unlikely*.<br>***Fuel/Combustible Loading and Ignition Source Control*** |
| The Waste Management Facilities will develop facility-specific Emergency Plans. | NPH Scenario 1<br>NPH Scenario 2 | Reduces the exposure of the IW to releases and prevents exposure of the IW to snow load-induced facility collapse.<br>***Emergency Response*** |

## 8.5 EXTERNAL EVENTS ACCIDENT ANALYSIS

### 8.5.1 External Events Scenario Development and Selection

In Section 6.1, *Hazard Evaluation*, aircraft crashes were identified as initiating a spill and fire. According to DOE-STD-3014-96 (Ref. 52), aircraft crashes may be screened to determine if a crash is a credible event for a facility.

The frequency of occurrence for a small aircraft crash as a function of target area has been analyzed in Emergency Planning Technical Report, 97-EPTR-004, *Analysis of Aircraft Crash Accidents at the Rocky Flats Environmental Technology Site* (Ref. 53). In terms of frequency, the greatest numbers of aircraft are represented by the small plane category associated with the Jefferson County Airport due to its operational volume and the closeness to the Site. The crash of a large aircraft at the Site is screened out as a possibility in 97-EPTR-004. Denver International Airport and the J-60 Jet Route are also screened out from the analysis using the methodology of the DOE-STD-3014-96 on analysis of aircraft accidents, because the airport is more than 12 miles from the Site and the center of the jet route is more than six miles from the Site. The technical report concluded the accident frequency involving Site facilities has been determined to be 7.67E-4 accidents/square mile-year. Using the methodology of the DOE-STD-3014-96 the effective area for an aircraft crash was calculated and determined to be 5.92E-3 square miles. Multiplying the accident frequency by the effective area of specific waste management facilities results in a frequency of occurrence of aircraft crashes/year for the specific facility. Table 8-32 lists the crash frequencies for waste management facilities on Site. Spreadsheets that document the calculation of the frequencies follow the table.

The DOE Standard directs consideration of "critical areas," possible impact approaches, and features that would act to limit the skid distance into the facility. Perforation due to aircraft crash was considered in 97-EPTR-004. The conclusion was that Single, Twin, and Turboprop aircraft would not perforate structures with 12 inch reinforced concrete walls and 4 inch reinforced concrete roofs. Most waste management facilities are Butler-type buildings that do not meet these criteria, and thus any aircraft crash is assumed to perforate the waste management facility. Since most waste management facilities are not located near other, non-waste management facilities, no modifications to approach is made, i.e., the facility is vulnerable to aircraft crashes from any direction. Also, due to this lack of protection, no modification to the skid distance prescribed by the Standard is made.

Inspection of Table 8-32 shows that for all waste management facilities where an aircraft crash is credible, the frequency is *extremely unlikely*.

**Table 8-32** Waste Management Facilities Aircraft Crash Frequencies

| BUILDING | CRASH FREQUENCY (per year) | COMMENTS |
|---|---|---|
| Building 440 | 3.73E-6 | |
| Building 460 | 1.05E-5 | Largest potential waste storage building on Site. Provides bounding highest frequency. |
| Building 569 | 1.36E-6 | Smallest waste storage building with a credible aircraft crash. Provides bounding lowest frequency. |
| Building 664 | 4.42E-6 | |
| Building 666 | < 1E-6 | Analyzed in the *Building 666 TSCA Waste Storage Facility* Facility Safety Analysis in the Site SAR (Ref. 2) |
| 750/904 Pad | 1.63E-6 | For Tent 3, the smallest tent on the 750/904 Pad. |
| Building 906 | 2.66E-6 | |
| Building 991 | < 1E-6 | Analyzed in NSTR-011-98, *Safety Analysis for the Building 991 Complex Final Safety Analysis Report* (Ref. 33). |
| RCRA Units | > 1E-6 | Analyzed in the *RCRA Storage Units* Facility Safety Analysis in the Site SAR (Ref. 2) |

## Building 440

| Aircraft Wingspan ft. | Building Length ft. | Building Width ft. | Building Height ft. | mean cot $\phi$ | Skid Distance ft. | Percent of 360° radius valid for impact |
|---|---|---|---|---|---|---|
| 50 | 276 | 142 | 20 | 8.2 | 68 | 100% |

| R ft. |
|---|
| 310.39 |

| $A_f$ ft$^2$ | $A_s$ ft$^2$ | $A_{eff}$ ft$^2$ | $A_{eff}$ mi$^2$ |
|---|---|---|---|
| 110,922.27 | 24,506.31 | 135,428.57 | 4.86E-03 |

| Crash frequency per year per square mile (From EPTR-004-97) |
|---|
| 7.67E-04 |

For Building 440. No protection provided by any other building, thus EPTR methodology (Building area × modified crash frequency) does not apply.

| Building specific crash frequency per year |
|---|
| 3.73E-06 |

| Critical area specific crash frequency per year |
|---|
| 3.73E-06 |

## Building 460

| Aircraft Wingspan ft. | Building Length ft. | Building Width ft. | Building Height ft. | mean cot ϕ | Skid Distance ft. | Percent of 360° radius valid for impact |
|---|---|---|---|---|---|---|
| 50 | 482 | 362 | 25 | 8.2 | 68 | 100% |

| R ft. |
|---|
| 602.80 |

| $A_f$ ft$^2$ | $A_s$ ft$^2$ | $A_{eff}$ ft$^2$ | $A_{eff}$ mi$^2$ |
|---|---|---|---|
| 337,253.61 | 44,390.41 | 381,644.02 | 1.37E-02 |

| | |
|---|---|
| Crash frequency per year per square mile (From EPTR-004-97) | 7.67E-04 |
| Building specific crash frequency per year | 1.05E-05 |
| Critical area specific crash frequency per year | 1.05E-05 |

For Building 460. No protection provided by any other building, thus EPTR methodology (Building area × modified crash frequency) does not apply.

## Building 569

| Aircraft Wingspan ft. | Building Length ft. | Building Width ft. | Building Height ft. | mean cot ϕ | Skid Distance ft. | Percent of 360° radius valid for impact |
|---|---|---|---|---|---|---|
| 50 | 127 | 60 | 15 | 8.2 | 68 | 100% |

| R ft. |
|---|
| 140.46 |

| $A_f$ ft$^2$ | $A_s$ ft$^2$ | $A_{eff}$ ft$^2$ | $A_{eff}$ mi$^2$ |
|---|---|---|---|
| 36,471.61 | 12,951.28 | 49,422.89 | 1.77E-03 |

| | |
|---|---|
| Crash frequency per year per square mile (From EPTR-004-97) | 7.67E-04 |
| Building specific crash frequency per year | 1.36E-06 |
| Critical area specific crash frequency per year | 1.36E-06 |

For Building 569. No protection provided by any other building, thus EPTR methodology (Building area × modified crash frequency) does not apply.



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## Building 664

| Aircraft Wingspan ft. | Building Length ft. | Building Width ft. | Building Height ft. | mean cot ϕ | Skid Distance ft. | Percent of 360° radius valid for impact |
|---|---|---|---|---|---|---|
| 50 | 200 | 150 | 40 | 8.2 | 68 | 100% |

| R ft. |
|---|
| 250.00 |

| $A_f$ ft$^2$ | $A_s$ ft$^2$ | $A_{eff}$ ft$^2$ | $A_{eff}$ mi$^2$ |
|---|---|---|---|
| 140,400.00 | 20,400.00 | 160,800.00 | 5.77E-03 |

| | |
|---|---|
| Crash frequency per year per square mile (From EPTR-004-97) | 7.67E-04 |
| Building specific crash frequency per year | 4.42E-06 |
| Critical area specific crash frequency per year | 4.42E-06 |

For Building 664. No protection provided by any other building, thus EPTR methodology (Building area × modified crash frequency) does not apply.

## 750/904 Pads

| Aircraft Wingspan ft. | Building Length ft. | Building Width ft. | Building Height ft. | mean cot ϕ | Skid Distance ft. | Percent of 360° radius valid for impact |
|---|---|---|---|---|---|---|
| 50 | 167 | 60 | 15 | 8.2 | 68 | 100% |

| R ft. |
|---|
| 177.45 |

| $A_f$ ft$^2$ | $A_s$ ft$^2$ | $A_{eff}$ ft$^2$ | $A_{eff}$ mi$^2$ |
|---|---|---|---|
| 43,643.14 | 15,466.70 | 59,109.83 | 2.12E-03 |

| | |
|---|---|
| Crash frequency per year per square mile (From EPTR-004-97) | 7.67E-04 |
| Building specific crash frequency per year | 1.63E-06 |
| Critical area specific crash frequency per year | 1.63E-06 |

For Smallest tent on 750/904 Pad. No protection provided by any other building, thus EPTR methodology (Building area × modified crash frequency) does not apply.

## Building 906

| Aircraft Wingspan ft. | Building Length ft. | Building Width ft. | Building Height ft. | mean cot $\phi$ | Skid Distance ft. | Percent of 360° radius valid for impact |
|---|---|---|---|---|---|---|
| 50 | 270 | 90 | 15 | 8.2 | 68 | 100% |

| R ft. |
|---|
| 284.60 |

| $A_f$ ft$^2$ | $A_s$ ft$^2$ | $A_{eff}$ ft$^2$ | $A_{eff}$ mi$^2$ |
|---|---|---|---|
| 73,994.56 | 22,753.14 | 96,747.70 | 3.47E-03 |

| Crash frequency per year per square mile (From EPTR-004-97) |
|---|
| 7.67E-04 |

| Building specific crash frequency per year |
|---|
| 2.66E-06 |

| Critical area specific crash frequency per year |
|---|
| 2.66E-06 |

For Building 906. No protection provided by any other building, thus EPTR methodology (Building area × modified crash frequency) does not apply.

### Representative Aircraft Crash Scenario

The representative aircraft crash scenario evaluated for waste management facilities is:

- Aircraft Crash Scenario 1 - Aircraft Crash-Induced LLW, TRU Spill and Fire

### 8.5.2 Aircraft Crash Scenario 1 - Aircraft Crash-Induced Spill and Fire

This accident scenario is discussed below and is summarized in Tables 8-27 and 8-29. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided the *Accident Consequences* section.

Accident Scenario

A 6,000-pound aircraft crashes into a waste management facility at 90 knots, causing physical damage to the structure and waste containers. A radiological release due to an aircraft crash consists of three release mechanisms each contributing to the calculated radiological dose: (1) a spill of drums that are breached by impact, (2) a subsequent fuel pool fire burning the unconfined contents of the drums breached by impact, and (3) the pool fire impacting additional drums within the pool fire area resulting in a confined material release (the drums are involved in the fire but were not breached by impact). The pool of fuel is expected to be 800 $ft^2$ (Ref. 53).

For Case A and Case B, seventy waste drums are assumed to be breached as the direct result of the crash impact (Ref. 54). The entire contents of the seventy breached drums is spilled and becomes involved in the subsequent pool fire resulting in an unconfined material release. An additional 410 drums within the pool fire area are also involved in the fire and result in a confined material release. For Case C, ten POCs are assumed to be breached as the direct result of the crash impact (Ref. 34). A portion of the contents of the ten breached POCs is spilled and becomes involved in the subsequent pool fire as unconfined material with the remaining unspilled portion involved as confined material. No additional POCs within the pool fire area are postulated to be involved beyond the ten that are breached by crash impact.

Three cases are evaluated for this scenario. Case A involves LLW drums, Case B involves TRU drums, and Case C involves POCs.

*Scenario Modeling Assumptions:* Case A, Case B, and Case C: spill; confined material; 10 minute duration; lofted fire; confined material; 10 minute duration; and lofted fire; unconfined combustibles; 10 minute duration.

Accident Frequency

Aircraft from the Jeffco Airport could crash into a Site building, thereby causing materials (including waste) to burn. As determined above, the frequency of an aircraft crashing into a waste management facility is *extremely unlikely* for Case A, Case B, and Case C.

*Scenario Modeling Assumption: extremely unlikely* event

Material at Risk

For Case A and Case B, it is postulated that 70 waste drums are breached by the physical impact of the aircraft crash (due to ***container integrity*** and based on kinetic energy available to be



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absorbed (Ref. 54)). Additionally, the ensuing pool fire involves the 70 breached drums plus 410 non-breached drums within the area of the pool fire. This results in a total of 480 drums at risk. To be conservative, 100 percent of the 70 breached drums are assumed to contain combustibles. The remaining 410 drums are assumed to remain confined after the aircraft crash.

Case A: ***Container fissile material loading*** for the waste management facilities allows up to 0.5 grams WG Pu equivalent to be contained in each LLW drum. Therefore, the MAR for breached combustibles is 35 grams of plutonium from breached containers. The MAR for intact drums of confined materials is 205 grams of plutonium. A "blended" dose conversion factor of 3.07E7 (Ref. 55) is used in modeling this scenario since more than 30 containers are involved. All contents of the containers are assumed to be involved, therefore the DR is 1.

Case B: ***Container fissile material loading*** for the waste management facilities allows up to 200 grams WG Pu equivalent to be contained in each TRU drum. Therefore, the MAR for breached combustibles is 14,000 grams of plutonium from breached containers. The MAR for intact drums of confined materials is 82,000 grams of plutonium. A "blended" dose conversion factor of 3.07E7 (Ref. 55) is used in modeling this scenario since more than 30 containers are involved. All contents of the containers are assumed to be involved, therefore the DR is 1.

Case C: Ten drums are assumed to be breached as the direct result of the crash impact (based on kinetic energy available to be absorbed). The amount of material at risk assumed is the most conservative ***container fissile material loading*** of plutonium and americium from a dose consequence standpoint. This would be 199 g of aged WG Pu and 16 g Americium per container. This amount can be modeled in RADIDOSE (Ref. 9) using either Solubility Class Y or W. The WG Pu equivalent amount using Solubility Class Y and Class W is 1,255 g and 883 g, respectively. From a dose consequence standpoint, it is more conservative to model the material at risk using the Class W amount of 883 g WG Pu equivalent. Therefore, the material at risk for the 10 Pipe Overpack Containers postulated to be involved in this scenario is 8,830 g WG Pu equivalent. A 10 percent damage ratio is credited due to the robustness of the POC (***container integrity***) Therefore, the final MAR is 10 percent of 10 Pipe Overpack Containers or 883 g WG Pu equivalent spilled as powder and burned as unconfined combustibles, and the remaining 90 percent or 7,947 g WG Pu equivalent burned as confined material. A fuel pool fire is assumed to occur, resulting in the burning of the unconfined as well as the confined material. Because the release fraction associated with Pipe Overpack Containers, any contribution from peripheral Pipe Overpack Containers in the pool fire would be negligible.

*Scenario Modeling Assumptions:*

Case A: 480 LLW drums, aged WG Pu, 240 grams, Blended DCF, DR = 1

Case B: 480 TRU drums, aged WG Pu, 96,000 grams, Blended DCF, DR = 1

Case C: 10 POC drums, aged WG Pu, 8,830 grams, Solubility Class W DCF, DR = 1

Accident Consequence

The crash and dose calculations are very conservative; this is evidenced by the following: (1) energy consumed in penetrating the building, although significant, is ignored, (2) no frictional



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losses are considered, (3) the maximum number of drums are breached, (4) optimal energy distribution to involve the maximum number of drums is assumed, (5) bounding MAR values are used, and (6) all of the breached drums are assumed to be combustibles.

Case A: The consequences from an aircraft crash fire are *moderate* to the MOI (0.21 rem @ 4,200 m, due to lofting), and *moderate* to the CW (7.7 rem). The resulting risk class is Risk Class III for both the MOI and CW (*extremely unlikely* frequency, *moderate* consequences). Table 8-33 shows the radiological dose component from the spill, unconfined material fire, and confined material fire release mechanisms.

For the IW located in the vicinity at the time of the event, the aircraft crash could result in death or serious injury. The radiological dose consequences to the IW are qualitatively judged to be *moderate* due to: (1) the indicators of an accident (*i.e.*, noise, verbal warnings, etc.) that inform the IW of the event; and (2) building ***emergency response*** and ***radiation protection*** guidance that directs the IW to evacuate. These controls mitigate the consequences of the event to the IW. The resulting risk class for this scenario is Risk Class III to the IW (*extremely unlikely* frequency, *moderate* consequences).

**Table 8-33** Aircraft Crash Scenario 1 – Case A; Radiological Dose Consequence Summary

| Dose Component | Material Form | Effective MAR (grams WG Pu Equivalent) | Collocated Worker Dose (rem) | MOI Dose (rem) | |
|---|---|---|---|---|---|
| | | | 100 m | 1,200 m | 2,367 m |
| Unconfined Combustible Material – Lofted Fire | Unconfined | 35 | 6.9E+00 (at 100 m) | 2.0E-01 (at 4,200 m) | 2.0E-01 (at 4,200 m) |
| Confined Material – Lofted Fire | Confined | 205 | 4.1E-01 (at 100 m) | 1.2E-02 (at 4,200 m) | 1.2E-02 (at 4,200 m) |
| Spill | Confined | 35 | 3.8E-01 (at 100 m) | 7.9E-03 (at 1,200 m) | 2.8E-03 (at 2,367 m) |
| Totals | – | 240 | 7.7E+00 (at 100 m) | ≈ 2.1E-01 to the MOI at 4,200m<br>< 7.9E-03 to the receptor between 1,200 m and 2,367 m | ≈ 2.1E-01 to the MOI at 4,200m<br>< 2.8E-03 to the receptor between 2,367 m and 4,200 m |

Case B: The consequences from an aircraft crash fire are *high* to the MOI (84 rem @ 4,200 m, due to lofting), and *high* to the CW (3,110 rem). The resulting risk class is Risk Class II for both the MOI and CW (*extremely unlikely* frequency, *high* consequences). Table 8-34 shows the radiological dose component from the spill, unconfined material fire, and confined material fire release mechanisms.

For the IW located in the vicinity at the time of the event, the aircraft crash could result in death or serious injury. The radiological dose consequences to the IW are qualitatively judged to be *moderate* due to: (1) the indicators of an accident (*i.e.*, noise, verbal warnings, etc.) that



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inform the IW of the event; and (2) building ***emergency response*** and ***radiation protection*** guidance that directs the IW to evacuate. These controls mitigate the consequences of the event to the IW. The resulting risk class for this scenario is Risk Class III to the IW (*extremely unlikely* frequency, *moderate* consequences).

**Table 8-34** Aircraft Crash Scenario 1 – Case B; Radiological Dose Consequence Summary

| Dose Component | Material Form | Effective MAR (grams WG Pu Equivalent) | Collocated Worker Dose (rem) | MOI Dose (rem) | |
|---|---|---|---|---|---|
| | | | 100 m | 1,200 m | 2,367 m |
| Unconfined Combustible Material – Lofted Fire | Unconfined | 14,000 | 2.8E+03 (at 100 m) | 7.9E+01 (at 4,200 m) | 7.9E+01 (at 4,200 m) |
| Confined Material – Lofted Fire | Confined | 82,000 | 1.6E+02 (at 100 m) | 4.6E+00 (at 4,200 m) | 4.6E+00 (at 4,200 m) |
| Spill | Confined | 14,000 | 1.5E+02 (at 100 m) | 3.2E+00 (at 1,200 m) | 1.1E+00 (at 2,367 m) |
| Totals | -- | 96,000 | 3.1E+03 (at 100 m) | ≈8.4E+01 to the MOI at 4,200m<br>< 3.2E+00 to the receptor between 1,200 m and 2,367 m | ≈8.4E+01 to the MOI at 4,200m<br>< 1.1E+00 to the receptor between 2,367 m and 4,200 m |

Case C: The consequences from an aircraft crash fire are *low* to the MOI (0.075 rem @ 4,200 m, due to lofting), and *moderate* to the CW (5.3 rem). The resulting risk class is Risk Class IV for the MOI, (*extremely unlikely* frequency, *low* consequences), and Risk Class III for the CW (*extremely unlikely* frequency, *moderate* consequences). Table 8-35 shows the radiological dose component from the spill, unconfined material fire, and confined material fire release mechanisms.

For the IW located in the vicinity at the time of the event, the aircraft crash could result in death or serious injury. The radiological dose consequences to the IW are qualitatively judged to be *moderate* due to: (1) the indicators of an accident (*i.e.*, noise, verbal warnings, etc.) that inform the IW of the event; and (2) building ***emergency response*** and ***radiation protection*** guidance that directs the IW to evacuate. These controls mitigate the consequences of the event to the IW. The resulting risk class for this scenario is Risk Class III to the IW (*extremely unlikely* frequency, *moderate* consequences).

**Table 8-35** Aircraft Crash Scenario 1 – Case C; Radiological Dose Consequence Summary

| Dose Component | Material Form | Effective MAR (grams WG Pu Equivalent) | Collocated Worker Dose (rem) | MOI Dose (rem) | |
|---|---|---|---|---|---|
| | | | 100 m | 1,200 m | 2,367 m |
| Unconfined Combustible Material – Lofted Fire | Unconfined | 883 | 2.4E+00 (at 100 m) | 6.9E-02 (at 4,200 m) | 6.9E-02 (at 4,200 m) |
| Confined Material – Lofted Fire | Confined | 7,947 | 2.2E-01 (at 100 m) | 6.2E-03 (at 4,200 m) | 6.2E-03 (at 4,200 m) |
| Spill | Powder | 883 | 2.7E+00 (at 100 m) | 5.6E-02 (at 1,200 m) | 2.0E-02 (at 2,367 m) |
| Totals | – | 8,830 | 5.3E+00 (at 100 m) | ≈ 7.5E-02 to the MOI at 4,200m<br>< 5.6E-02 to the receptor between 1,200 m and 2,367 m | ≈7.5E-02 to the MOI at 4,200m<br>< 2.0E-02 to the receptor between 2,367 m and 4,200 m |

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.50E+01 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Aircraft Crash - LLW
Spill Component
70 Drums, Confined Materials, Blended DCF
1,200 meters

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| Default Parameters | | Change Options | | |
|---|---|---|---|---|
| | | Accept Default? | New Value | Value Used |
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.07E+07 | 3.07E+07 |
| Effective MAR, Including DR (g) = | 3.50E+01 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 3.8E-01 | 7.9E-03 |
| One | 3.8E-04 | 7.9E-06 |
| Two | 7.7E-07 | 1.6E-08 |
| Three | 1.5E-09 | 3.2E-11 |
| Four | 3.1E-12 | 6.3E-14 |

Respirable Initial Source Term (g) = 3.50E-03

**Aircraft Crash Scenario 1 – Case A; Radiological Dose; Spill Component; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.50E+01 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Aircraft Crash - LLW
Spill Component
70 Drums, Confined Materials, Blended DCF
2,367 meters

Version 1.2

| Default Parameters | | Change Options | | |
|---|---|---|---|---|
| | | Accept Default? | New Value | Value Used |
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.07E+07 | 3.07E+07 |
| Effective MAR, Including DR (g) = | 3.50E+01 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 3.8E-01 | 2.8E-03 |
| One | 3.8E-04 | 2.8E-06 |
| Two | 7.7E-07 | 5.6E-09 |
| Three | 1.5E-09 | 1.1E-11 |
| Four | 3.1E-12 | 2.3E-14 |

Respirable Initial Source Term (g) = 3.50E-03

**Aircraft Crash Scenario 1 – Case A; Radiological Dose; Spill Component; 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.50E+01 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - LLW
Fire Component
70 Drums, Unconfined Combustibles Blended DCF
1,200 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 3.50E+01 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted); 100 m (lofted); MOI at 1200 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 1.75E+00

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-02 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 6.9E+00 | 2.0E-01 |
| One | 1.9E-01 | 4.0E-03 |
| Two | 3.8E-04 | 7.9E-06 |
| Three | 7.7E-07 | 1.6E-08 |
| Four | 1.5E-09 | 3.2E-11 |

**Aircraft Crash Scenario 1 – Case A; Radiological Dose; Fire Component (unconfined material); 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.50E+01 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - LLW
Fire Component
70 Drums, Unconfined Combustibles Blended DCF
2,367 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 3.50E+01 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 2367 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 1.75E+00

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-02 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 6.9E+00 | 2.0E-01 |
| One | 1.9E-01 | 1.4E-03 |
| Two | 3.8E-04 | 2.8E-06 |
| Three | 7.7E-07 | 5.6E-09 |
| Four | 1.5E-09 | 1.1E-11 |

**Aircraft Crash Scenario 1 – Case A; Radiological Dose; Fire Component (unconfined material); 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 2.05E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - LLW
Fire Component
410 Drums, Confined Materials Blended DCF
1,200 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 2.05E+02 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 1200 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 1.03E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 4.1E-01 | 1.2E-02 |
| One | 1.1E-02 | 2.3E-04 |
| Two | 2.3E-05 | 4.6E-07 |
| Three | 4.5E-08 | 9.3E-10 |
| Four | 9.0E-11 | 1.9E-12 |

**Aircraft Crash Scenario 1 – Case A; Radiological Dose; Fire Component (confined material); 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 2.05E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - LLW
Fire Component
410 Drums, Confined Materials Blended DCF
2,367 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 2.05E+02 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 2367 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 1.03E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 4.1E-01 | 1.2E-02 |
| One | 1.1E-02 | 8.3E-05 |
| Two | 2.3E-05 | 1.7E-07 |
| Three | 4.5E-08 | 3.3E-10 |
| Four | 9.0E-11 | 6.6E-13 |

**Aircraft Crash Scenario 1 – Case A; Radiological Dose; Fire Component (confined material); 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.40E+04 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - TRU
Spill Component
70 Drums, Confined Materials, Blended DCF
1,200 meters
Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.07E+07 | 3.07E+07 |
| Effective MAR, Including DR (g) = | 1.40E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 1.5E+02 | 3.2E+00 |
| One | 1.5E-01 | 3.2E-03 |
| Two | 3.1E-04 | 6.3E-06 |
| Three | 6.1E-07 | 1.3E-08 |
| Four | 1.2E-09 | 2.5E-11 |

Respirable Initial Source Term (g) = 1.40E+00

**Aircraft Crash Scenario 1 – Case B; Radiological Dose; Spill Component; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.40E+04 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - TRU
Spill Component
70 Drums, Confined Materials, Blended DCF
2,367 meters
Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.07E+07 | 3.07E+07 |
| Effective MAR, Including DR (g) = | 1.40E+04 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 1.5E+02 | 1.1E+00 |
| One | 1.5E-01 | 1.1E-03 |
| Two | 3.1E-04 | 2.3E-06 |
| Three | 6.1E-07 | 4.5E-09 |
| Four | 1.2E-09 | 9.0E-12 |

Respirable Initial Source Term (g) = 1.40E+00

**Aircraft Crash Scenario 1 – Case B; Radiological Dose; Spill Component; 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.40E+04 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:

Aircraft Crash - TRU
Fire Component
70 Drums, Unconfined Combustibles, Blended DCF
1,200 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 1.40E+04 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-02 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.8E+03 | 7.9E+01 |
| One | 7.7E+01 | 1.6E+00 |
| Two | 1.5E-01 | 3.2E-03 |
| Three | 3.1E-04 | 6.3E-06 |
| Four | 6.1E-07 | 1.3E-08 |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.

CW at 100 m (non-lofted), 100 m (lofted); MOI at 1200 m (non-lofted), 4200 m (lofte

Respirable Initial Source Term (g) = 7.00E+02

**Aircraft Crash Scenario 1 – Case B; Radiological Dose; Fire Component (unconfined material); 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 1.40E+04 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:

Aircraft Crash - TRU
Fire Component
70 Drums, Unconfined Combustibles, Blended DCF
2,367 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 1.40E+04 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-02 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.8E+03 | 7.9E+01 |
| One | 7.7E+01 | 5.6E-01 |
| Two | 1.5E-01 | 1.1E-03 |
| Three | 3.1E-04 | 2.3E-06 |
| Four | 6.1E-07 | 4.5E-09 |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.

CW at 100 m (non-lofted), 100 m (lofted); MOI at 2367 m (non-lofted), 4200 m (lofte

Respirable Initial Source Term (g) = 7.00E+02

**Aircraft Crash Scenario 1 – Case B; Radiological Dose; Fire Component (unconfined material); 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 8.20E+04 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - TRU
Fire Component
410 Drums, Confined Materials, Blended DCF
1,200 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 8.20E+04 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 1200 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 4.10E+01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 1.6E+02 | 4.6E+00 |
| One | 4.5E+00 | 9.3E-02 |
| Two | 9.0E-03 | 1.9E-04 |
| Three | 1.8E-05 | 3.7E-07 |
| Four | 3.6E-08 | 7.4E-10 |

**Aircraft Crash Scenario 1 – Case B; Radiological Dose; Fire Component (confined material); 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 8.20E+04 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - TRU
Fire Component
410 Drums, Confined Materials, Blended DCF
2,367 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | |
| Effective MAR, Including DR (g) = | 8.20E+04 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q ($s/m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 1.02E-05 | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 2367 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 4.10E+01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| N | 3.07E+07 | 3.07E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 1.6E+02 | 4.6E+00 |
| One | 4.5E+00 | 3.3E-02 |
| Two | 9.0E-03 | 6.6E-05 |
| Three | 1.8E-05 | 1.3E-07 |
| Four | 3.6E-08 | 2.6E-10 |

**Aircraft Crash Scenario 1 – Case B; Radiological Dose; Fire Component (confined material); 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 1 | WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 6 | Powder |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 8.83E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - POC
Spill Component
10 POCs, Powder, Class W DCF
1,200 meters

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 2.0E-03 | Y | | 2.0E-03 |
| Respirable Fraction = | 3.0E-01 | N | 1.0E-02 | 1.0E-02 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.28E+07 | Y | | 4.28E+07 |
| Effective MAR, Including DR (g) = | 8.83E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.7E+00 | 5.6E-02 |
| One | 2.7E-03 | 5.6E-05 |
| Two | 5.4E-06 | 1.1E-07 |
| Three | 1.1E-08 | 2.2E-10 |
| Four | 2.2E-11 | 4.5E-13 |

Respirable Initial Source Term (g) = 1.77E-02

**Aircraft Crash Scenario 1 – Case C; Radiological Dose; Spill Component; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 1 | WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 6 | Powder |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 8.83E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - POC
Spill Component
10 POCs, Powder, Class W DCF
2,367 meters

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 2.0E-03 | Y | | 2.0E-03 |
| Respirable Fraction = | 3.0E-01 | N | 1.0E-02 | 1.0E-02 |
| Breathing Rate ($m^3/s$) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.28E+07 | Y | | 4.28E+07 |
| Effective MAR, Including DR (g) = | 8.83E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 | | | |
| Public χ/Q ($s/m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.7E+00 | 2.0E-02 |
| One | 2.7E-03 | 2.0E-05 |
| Two | 5.4E-06 | 4.0E-08 |
| Three | 1.1E-08 | 7.9E-11 |
| Four | 2.2E-11 | 1.6E-13 |

Respirable Initial Source Term (g) = 1.77E-02

**Aircraft Crash Scenario 1 – Case C; Radiological Dose; Spill Component; 2,367 m**



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# Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 1 | WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 8.83E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Aircraft Crash - POC
Fire Component
10 POCs, Unconfined Combustibles, Class W DCF
1,200 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.28E+07 | |
| Effective MAR, Including DR (g) = | 8.83E+02 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 3.59E-04 | 9.94E-03 |
| Public $\chi$/Q (s/$m^3$) = | 1.02E-05 | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.

CW at 100 m (non-lofted), 100 m (lofted); MOI at 1200 m (non-lofted), 4200 m (lofte

Respirable Initial Source Term (g) = 4.42E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-02 |
| N | 1.0E-02 | 1.0E-02 |
| Y | | 3.6E-04 |
| Y | | 4.28E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 2.4E+00 | 6.9E-02 |
| One | 6.8E-02 | 1.4E-03 |
| Two | 1.4E-04 | 2.8E-06 |
| Three | 2.7E-07 | 5.6E-09 |
| Four | 5.4E-10 | 1.1E-11 |

**Aircraft Crash Scenario 1 – Case C; Radiological Dose; Fire Component (unconfined material); 1,200 m**

# Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 1 | WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.100 | |
| Material at Risk (g) = | 8.83E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Aircraft Crash - POC
Fire Component
10 POCs, Unconfined Combustibles, Class W DCF
2,367 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.28E+07 | |
| Effective MAR, Including DR (g) = | 8.83E+02 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 3.59E-04 | 9.94E-03 |
| Public $\chi$/Q (s/$m^3$) = | 1.02E-05 | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.

CW at 100 m (non-lofted), 100 m (lofted); MOI at 2367 m (non-lofted), 4200 m (lofte

Respirable Initial Source Term (g) = 4.42E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-02 |
| N | 1.0E-02 | 1.0E-02 |
| Y | | 3.6E-04 |
| Y | | 4.28E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 2.4E+00 | 6.9E-02 |
| One | 6.8E-02 | 5.0E-04 |
| Two | 1.4E-04 | 9.9E-07 |
| Three | 2.7E-07 | 2.0E-09 |
| Four | 5.4E-10 | 4.0E-12 |

**Aircraft Crash Scenario 1 – Case C; Radiological Dose; Fire Component (unconfined material); 2,367 m**



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 1 | WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.900 | |
| Material at Risk (g) = | 8.83E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - POC
Fire Component
10 POCs, Confined Materials, Class W DCF
1,200 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.28E+07 | |
| Effective MAR, Including DR (g) = | 7.95E+03 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q (s/$m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q (s/$m^3$) = | 1.02E-05 | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 1200 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 3.97E-02

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| N | 1.0E-02 | 1.0E-02 |
| Y | | 3.6E-04 |
| Y | | 4.28E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.2E-01 | 6.2E-03 |
| One | 6.1E-03 | 1.3E-04 |
| Two | 1.2E-05 | 2.5E-07 |
| Three | 2.4E-08 | 5.0E-10 |
| Four | 4.9E-11 | 1.0E-12 |

**Aircraft Crash Scenario 1 – Case C; Radiological Dose; Fire Component (confined material); 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 1 | Fire, Lofted Plum |
| Material (1-8) = | 1 | WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.900 | |
| Material at Risk (g) = | 8.83E+03 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Aircraft Crash - POC
Fire Component
10 POCs, Confined Materials, Class W DCF
2,367 meters

Version 1.2

| Default Parameters | Lofted Values | Non-Lofted X/Q |
|---|---|---|
| Airborne Release Fraction = | 5.0E-04 | |
| Respirable Fraction = | 1.0E+00 | |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | |
| Dose Conversion Factor (rem/g-mix) = | 4.28E+07 | |
| Effective MAR, Including DR (g) = | 7.95E+03 | |
| Plume Expansion Factor = | 1.000 | |
| Collocated Worker χ/Q (s/$m^3$) = | 3.59E-04 | 9.94E-03 |
| Public χ/Q (s/$m^3$) = | 1.02E-05 | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | |

Doses that credit HEPA filtration are based upon non-lofted X/Q values.
CW at 100 m (non-lofted), 100 m (lofted); MOI at 2367 m (non-lofted), 4200 m (lofte
Respirable Initial Source Term (g) = 3.97E-02

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 5.0E-04 |
| N | 1.0E-02 | 1.0E-02 |
| Y | | 3.6E-04 |
| Y | | 4.28E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.2E-01 | 6.2E-03 |
| One | 6.1E-03 | 4.5E-05 |
| Two | 1.2E-05 | 8.9E-08 |
| Three | 2.4E-08 | 1.8E-10 |
| Four | 4.9E-11 | 3.6E-13 |

**Aircraft Crash Scenario 1 – Case C; Radiological Dose; Fire Component (confined material); 2,367 m**



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## Table 8-36 Aircraft Crash Scenario 1, Case A - LLW Drums Impacted by Aircraft Crash

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Aircraft Crash impacting 480 LLW drums<br>Effective MAR = 35 grams of aged WG Pu unconfined, 205 grams of aged WG Pu confined; accident can occur in waste storage areas and receipt/shipment areas |
| Cause or Energy Source | [energy sources] 13H (Natural Phenomena or External Events) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type | Feature Purpose | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | Credited Defense | Prevent Mitigate | |
| MOI | Extremely Unlikely | Extremely Unlikely | Not Applicable | @ 4,200 m due to lofting<br>Moderate 0.21 rem | Not Applicable | @ 4,200 m due to lofting<br>III | Container Integrity<br>Container Fissile Material Loading | C<br>C | M<br>M | AOL 1<br>AOL 4 |
| CW | Extremely Unlikely | Extremely Unlikely | Not Applicable | Moderate 7.7 rem | Not Applicable | III | Same as MOI | | | |
| IW | Extremely Unlikely | Extremely Unlikely | Not Applicable | Moderate | Not Applicable | III | Emergency Response<br>Radiation Protection | C<br>C | M<br>M | AC 5.5<br>AC 5.6 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 8-37 Aircraft Crash Scenario 1, Case B - TRU Drums Impacted by Aircraft Crash

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Aircraft Crash impacting 480 TRU drums<br>Effective MAR = 14,000 grams of aged WG Pu unconfined, 82,000 grams of aged WG Pu confined; accident can occur in waste storage areas and receipt/shipment areas |
| Cause or Energy Source | [energy sources] 13H (Natural Phenomena or External Events) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Extremely Unlikely | Extremely Unlikely | Not Applicable | @ 4,200 m due to lofting<br>High<br>84 rem | Not Applicable | @ 4,200 m due to lofting<br>II | Container Integrity<br>Container Fissile Material Loading | C<br>C | M<br>M | AOL 1<br>AOL 4 |
| CW | Extremely Unlikely | Extremely Unlikely | Not Applicable | High<br>3,110 rem | Not Applicable | II | Same as MOI | | | |
| IW | Extremely Unlikely | Extremely Unlikely | Not Applicable | Moderate | Not Applicable | III | Emergency Response<br>Radiation Protection | C<br>C | M<br>M | AC 5.5<br>AC 5.6 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 8-38 Aircraft Crash Scenario 1, Case C - POC Drums Impacted by Aircraft Crash

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Aircraft Crash impacting 480 TRU drums<br>Effective MAR = 883 grams of aged WG Pu Powder/Unconfined (DR = 0.1) 7,947 grams of aged WG Pu confined; accident can occur in waste storage areas and receipt/shipment areas |
| Cause or Energy Source | [energy sources] 13H (Natural Phenomena or External Events) |
| Applicable Activity(ies) | [most likely] SH; [less likely] CC, CR, RT, GN, RA |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Extremely Unlikely | Extremely Unlikely | Not Applicable | @ 4,200 m due to lofting<br>Low<br>0.075 rem | Not Applicable | @ 4,200 m due to lofting<br>IV | Container Integrity<br>Container Fissile Material Loading | C<br>C | M<br>M | AOL 1<br>AOL 4 |
| CW | Extremely Unlikely | Extremely Unlikely | Not Applicable | Moderate<br>5.3 rem | Not Applicable | III | Same as MOI | | | |
| IW | Extremely Unlikely | Extremely Unlikely | Not Applicable | Moderate | Not Applicable | III | Emergency Response<br>Radiation Protection | C<br>C | M<br>M | AC 5.5<br>AC 5.6 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

### 8.5.3 Control Set Adequacy/Vulnerability

No preventive features have been credited in the determination of aircraft crash scenario frequencies. Four mitigative features have been credited in determination of spill scenario consequences.

The credited mitigative features are:

1. the Administrative Control for ***container integrity*** requirements (MOI and CW);
2. the Administrative Control of ***container fissile material loading*** (MOI and CW);
3. the Administrative Control for ***radiation protection*** (IW only); and
4. the Administrative Control for ***emergency response*** (IW only).

Failure of the ***container integrity*** mitigative feature (*e.g.*, inadequate container) increases the number of waste containers that will breach due to puncture by the aircraft. An increase in the number of waste containers involved would result in additional MAR and a corresponding increase in the radiological dose consequences.

Failure of the ***container fissile material loading*** mitigative feature (*e.g.*, underestimation of container radiological inventory, over batching, etc.) would result in additional MAR and a corresponding increase in the radiological dose consequences.

Failures of the ***radiation protection*** or the ***emergency response*** SMPs (inadequate response to radioactive material spill) can result in increased IW exposure to airborne radioactive materials. This can increase the spill scenario consequences for the IW from *low* to *moderate* due to the higher radiological dose associated with a longer exposure time.

### 8.5.4 Aircraft Crash Scenario Assumptions

In the evaluation of the aircraft crash scenario, assumptions are identified for prevention and/or mitigation of the accidents. Table 8-39 presents a listing of the assumptions specified in the evaluation of aircraft crash scenarios. The scenarios/cases to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*



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**Table 8-39** Aircraft Crash Scenario Assumptions

| ASSUMPTION | SCENARIO CODE | ASSUMPTION IMPACT |
|---|---|---|
| LLW containers contain no more than 0.5 grams WG Pu equivalent in drums and 3 grams WG Pu equivalent in metal boxes. | Aircraft Crash Scenario 1, Case A | Sets the potential MAR for the scenario impacting LLW containers. ***Container Fissile Material Loading*** |
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs. | Aircraft Crash Scenario 1, Case B | Sets the potential MAR for the scenario impacting TRU waste containers. ***Container Fissile Material Loading*** |
| POC waste containers contain no more than 1,255 grams (WG Pu equivalent). | Aircraft Crash Scenario 1, Case C | Sets the potential MAR for the scenario impacting POC waste containers. ***Container Fissile Material Loading*** |
| Metal waste containers are resistant to impacts due to aircraft crash. | Aircraft Crash Scenario 1, all cases | Sets the number of waste containers that will be breached in the aircraft crash. ***Container Integrity*** |
| The Waste Management Facilities will comply with the Radiation Protection program. | Aircraft Crash Scenario 1, all cases | Reduces the exposure to the IW to releases. ***Radiation Protection*** |
| The Waste Management Facilities will develop facility-specific Emergency Plans. | Aircraft Crash Scenario 1, all cases | Reduces the exposure to the IW to releases. ***Emergency Response*** |

# 9. WASTE CHARACTERIZATION – CHEMICAL (CC) ACCIDENT ANALYSIS

This section presents the accident analysis for the following fire, spill, and explosion accident scenarios associated with CC activities as identified in Section 6.2.2, *Waste Characterization – Chemical (CC) Accident Scenarios*.

***Reserved***

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# 10. WASTE CHARACTERIZATION – RADIOLOGICAL (CR) ACCIDENT ANALYSIS

This section presents the accident analysis for the following fire, spill, and explosion accident scenarios associated with CR activities as identified in Section 6.2.3, *Waste Characterization – Radiological (CR) Accident Scenarios*.

***Reserved***



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# 11. REPACKAGING AND TREATMENT (RT) ACCIDENT ANALYSIS

This section presents the accident analysis for the following fire and spill scenarios associated with RT activities as identified in Section 6.2.4, *Repackaging and Treatment (RT) Accident Scenarios,* and Table 6-3:

Fire:
- Confinement Enclosure

Spill:
- Confinement Enclosure

## 11.1 FIRE SCENARIO ACCIDENT ANALYSIS

### 11.1.1 Fire Scenario Development and Selection

Waste staging, storage, and handling activities are conducted to support RT activities. Representative accident scenarios associated with such activities are presented in Section 8, *Storage and Handling (SH) Accident Analysis,* and are not duplicated in this section. RT activities are unique in that waste containers are opened as part of the process of repackaging and treatment. Therefore, RT accident analysis is focused on scenarios involving open waste containers.

Waste repackaging involves opening either LLW or TRU waste containers, sorting the contents, and repackaging the contents into appropriate waste containers. However, treatment activities are limited to LLW. Site Closure planning does not currently include onsite treatment of TRM waste. LLW containers are usually opened inside a confinement enclosure such as a Perma-Con or contamination cell (C-cell). In fact, when the level of radioactivity is determined to be sufficiently low, LLW containers may be opened outside of a confinement enclosure. TRU waste containers are only opened inside a HEPA filtered confinement enclosure (*e.g.*, glovebox) located in a confinement area. Confinement areas are equipped with HEPA ventilation (***filtered exhaust ventilation system***) and are covered by a facility ***automatic sprinkler system***.

During RT activities, fires may impact the radioactive material inventories of (1) closed waste containers staged for repackaging or treatment, or (2) open waste containers being repackaged or treated. For closed waste containers an ignition source is assumed to come into direct contact with transient flammable/combustible materials in close proximity to the waste container(s) as discussed in the SH accident analysis (Ref. Chapter 8). For open waste containers, an ignition source is assumed to come into direct contact with either (1) exposed combustible waste inside a waste container, or (2) transient flammable/combustible materials in close proximity to the open waste container(s). The types of fires postulated for the RT activity module are: (1) fires inside confinement enclosures, (2) fires outside confinement enclosures but inside confinement areas (*e.g.*, areas with HEPA ventilation), and (3) fires in areas without confinement (LLW only).

The ***fuel/combustible loading and ignition source control*** program restricts the introduction of transient flammable/combustible materials into RT areas. This program also



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restricts wooden crates from most waste storage areas. Fire scenarios involving wooden waste crates are not evaluated in this NSTR revision. In order to model representative fire scenarios, it is assumed that transient combustible material is located in close proximity to LLW boxes or TRU waste containers. Such a condition represents a failure of the ***fuel/combustible loading and ignition source control*** program.

The MAR values associated with the container types evaluated in the fire scenarios are presented in Table 11-1.

**Table 11-1** Fire Scenario MAR Values

| CONTAINER TYPE | CONTAINER CONFIGURATION | MAXIMUM MAR (WG Pu equivalent) | EFFECTIVE MAR (WG Pu equivalent) |
|---|---|---|---|
| Metal LLW box | single | 3 grams | 3 grams |
| Metal LLW drum | single | 0.5 grams | 0.5 grams |
| Metal LLW drum[1] | pallet, 4 containers | 2 grams | 1.5 grams |
| TRUPACT II SWB or metal waste box | single | 320 grams | 320 grams |
| TRU drum | single | 200 grams | 200 grams |
| TRU drum[1] | pallet, 4 containers | 800 grams | 600 grams |

1. The involvement of 4 palletized waste drums in facility fire scenarios is assumed to be 3 drums.

Based on the information in Table 11-1, the bounding container type for single-container LLW fire scenarios is the metal box (3 g WG Pu per box versus 0.5 g WG Pu per drum). The bounding container type for single-container TRU waste scenarios is the SWB/box (320 g WG Pu versus 200 g WG Pu). For multiple container fire scenarios, the bounding container type for LLW is the metal box (3 g WG Pu per box versus 0.5 g WG Pu per drum); the bounding container type for TRU waste is three drums as discussed in the facility fire scenario in Section 8.1.2.

#### 11.1.1.1 1 MW Fire in RT Confinement Area

A 1 MW fire starts inside an RT confinement area (but outside a confinement enclosure) involving combustible materials located in close proximity to waste containers staged for repackaging or treatment. The fire is assumed to generate enough heat and combustion products to cause heating, pyrolysis, and venting of containers. Three drums or one waste box are postulated to be involved in this fire which is essentially the same as the facility fire evaluated in Section 8.1.2, *Fire Scenario 1 – 1 MW Waste Container Fire*, and thus the evaluation is not presented again in this section.

A 1 MW fire occurring in a confinement area would be bounded by the same 1 MW fire occurring during SH activities because (1) the 1 MW fire scenario would be modeled the same for both RT and SH activities, (2) operable filtration systems can be credited in confinement areas (if



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present), and (3) a confinement area LPF of less than 1.0, which is the default value used in evaluating the 1 MW occurring during SH activities, can be credited.

**11.1.1.2** 4 MW Fire in the RT Confinement Area

A 4 MW fire starts inside an RT confinement area (but outside a confinement enclosure) involving combustible materials located in close proximity to waste containers staged for repackaging or treatment. The fire is assumed to generate enough heat and combustion products to cause heating, pyrolysis, and venting of containers. Nine TRU waste drums or two LLW boxes are postulated to be involved in this fire which is essentially the same as the facility fire evaluated in Section 8.1.3, *Fire Scenario 2 – 4 MW Waste Container Fire*, and thus the evaluation is not presented again in this section.

A 4 MW fire occurring in a confinement area would be bounded by the same 4 MW fire occurring during SH activities because (1) the 4 MW fire scenario would be modeled the same for both RT and SH activities, (2) operable filtration can be credited in confinement areas (if present), and (3) a confinement area LPF of less than 1.0, which is the default value used in evaluating the 4 MW occurring during SH activities, can be credited.

**11.1.1.3** Small Fire in the RT Confinement Enclosure

A small fire ignites exposed waste materials being repackaged or treated in a RT confinement enclosure (*e.g.*, glovebox, C-cell, Perm-Con, etc.). The scenario can involve LLW being treated or materials being repackaged into a LLW box or TRU waste box/SWB. This scenario is evaluated further in Section 11.1.2 as a representative fire scenario for RT activities.

**11.1.1.4** Representative Fire Scenario

The representative fire scenario evaluated for waste management facility RT activities is:

- Fire Scenario 3 - Small Fire in Repackaging Confinement Enclosure

### 11.1.2 Fire Scenario 3 - Small Fire in Repackaging Confinement Enclosure

This accident scenario is discussed below and is summarized in Tables 11-2 and 11-3. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

Case A: This case postulates initiation of a small fire inside an RT confinement enclosure that ignites combustible LLW waste exposed during repackaging or treatment. A LLW waste box may consist of hundreds of pounds of combustible waste.

Combustible LLW waste exposed during repackaging or treatment ignites, consuming all the contents of a waste box and breaches the confinement enclosure. Potential ignition or Hazard/Energy Sources for the fire are: *5B (Flammable Gases), 5E (Electrical Power Systems),* *13B (Incompatible Chemicals),* or *13G (Combustibles).* It is assumed that there is sufficient separation distance between the RT confinement enclosure and other waste containers staged outside the confinement enclosure such that a fire will not propagate.

The representative fire scenario for LLW repackaging and treatment activities is a fire within a Perma-Con or C-cell that involves the contents of one waste box, and breaches the confinement enclosure. A non-lofted plume of unconfined radioactive material was assumed in determining the consequences for fires of this size. The fire is conservatively assumed to be of short duration such that a release over 10 minutes is analyzed.

Case B: This case postulates initiation of a small fire inside an RT confinement enclosure (glovebox) that ignites combustible TRU waste materials exposed during repackaging. The TRU waste may consist of hundreds of pounds of combustible waste.

Combustible TRU waste exposed for repackaging ignites, consuming all the TRU waste. If the fire is not mitigated by the ***glovebox fire suppression system***, it breaches the confinement enclosure. Potential ignition or Hazard/Energy Sources for the fire are: *5B (Flammable Gases), 5E (Electrical Power Systems), 13B (Incompatible Chemicals, 13G (Combustibles), or 13H (NPH/EE-fire).* It is assumed that there is sufficient separation distance from the RT glovebox waste to other waste staged (closed containers) in the confinement area such that a fire in the RT glovebox will not propagate. While the glovebox gloves and HEPA filters may be consumed by the fire, it is assumed that the ***fuel/combustible loading and ignition source control*** program is implemented preventing fire propagation. In addition, the facility ***automatic sprinkler system*** and confinement area ***filtered exhaust ventilation system*** are credited for mitigating the fire if the glovebox is breached.

The representative RT fire for TRU waste is a glovebox fire that involves waste materials within the glovebox. It is conservatively estimated that 320 grams of WG Pu (the glovebox criticality limit, which is an attribute of the ***Criticality Safety*** SMP) is being processed inside the glovebox. A non-lofted plume of unconfined radioactive material was assumed in determining the consequences for this fire. The fire is conservatively assumed to be of short duration such that a release over 10 minutes is analyzed.

Four controls are credited in preventing propagation of a glovebox fire. The initial control is the ***glovebox fire suppression system.*** This system may remain operationally independent of the building ***automatic sprinkler system*** during fires. The ***glovebox fire suppression system*** is assumed to actuate and mitigate the fire, limiting the amount of waste material involved. The fire would likely be limited to some portion of the glovebox contents; however, it was conservatively assumed that the entire contents are involved. The ***glovebox filtered exhaust system*** would mitigate the release in this situation.

The next control is glovebox integrity (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control). While a fire may breach the glovebox HEPA filters or gloves, it is assumed that the structure will prevent the fire from propagating outside the glovebox.

Another control is the facility ***automatic sprinkler system*** that prevents the fire from propagating and involving nearby waste containers that may be staged outside the glovebox. Failure of the ***glovebox fire suppression system*** and a subsequent breach of the glovebox structure may result in actuation of the facility ***automatic sprinkler system***. Upon actuation, the system is assumed to contain the fire within the confinement area (*i.e.*, the system actuates before the fire spreads to involve containers exterior to the glovebox). The confinement area ***filtered exhaust system*** is assumed to mitigate the release in this situation.

The final control is the ***Fire Department notification and response***. The Fire Department can be notified of a fire by building personnel via ***fire phones*** or by flow alarms from the facility ***automatic sprinkler system***. Fire Department response limits the fire to the contents of the confinement area.

*Scenario Modeling Assumptions*; fire; unconfined combustible waste; 10-minute duration; non-lofted plume.

Accident Frequency

Case A: The likelihood of this postulated LLW fire accident scenario is judged to be *anticipated* without prevention, and *unlikely* with prevention, because of the following considerations: (1) fire occurrence is generally considered to be an *anticipated* event although not as frequent as once per year, (2) the limited amount of electrical service provided to the confinement enclosure, (3) the limited amount of fuel/combustible loading (an attribute of the ***fuel/combustible loading and ignition source control*** program). For Case B, the likelihood of the fire involving TRU waste is judged to be *anticipated* without prevention and *unlikely* with prevention because of the same three LLW considerations as well as the actuation of the ***glovebox fire suppression system***. The ***glovebox fire suppression system*** is credited with suppressing any fire in the glovebox to a level such that only waste material in the glovebox is impacted and the fire does not propagate outside.

*Scenario Modeling Assumptions*: an *unlikely* event.

Material-at-Risk

Case A: It is conservatively assumed that the confinement enclosure is breached by the fire and all of its contents are released (*i.e.*, DR = 1.0). Waste management facilities allow up to 3 grams WG Pu equivalent to be contained in each LLW crate, equivalent to the quantities assumed in the confinement enclosure. Therefore, the total effective MAR for the postulated scenario is 3 grams of WG Pu. The material is assumed to be aged WG Pu and Solubility Class W.

Case B: It is conservatively assumed that the entire contents of the glovebox is involved in the fire and is subject to release (*i.e.*, DR = 1.0). The glovebox criticality limit (an attribute of the ***Criticality Safety*** SMP) is credited for limiting the confinement enclosure contents to a maximum of 320 grams of WG Pu. In a mitigated situation, the ***glovebox fire suppression system*** activates and ***glovebox filtered exhaust ventilation system*** provides a 1E-3 leakpath reduction. In an unmitigated situation, the ***glovebox fire suppression system*** and the ***glovebox filtered exhaust ventilation system*** both fail, allowing the fire to breach the glovebox. Also in the unmitigated situation, the confinement area ***filtered exhaust ventilation system*** fails.

*Scenario Modeling Assumptions*:

Case A: aged WG Pu; 3 grams; Solubility Class W DCF; DR = 1.0.

Case B: aged WG Pu; 320 grams; Solubility Class W DCF; DR = 1.0.

Accident Consequences

Case A: The radiological dose consequences of the LLW box fire in the confinement enclosure are *low* (0.48 rem) to the MOI @ 1,200 meters, *low* (0.17 rem) to the MOI @ 2,367 meters, and *moderate* (23 rem) to the collocated worker. Due to the configuration of the LLW repackaging and treatment operation, ***filtered exhaust ventilation system*** is not credited with reducing the dose consequences in this scenario. The resulting risk class for the scenario is Risk Class III for the MOI @ 1,200 meters and 2,367 meters (*unlikely* frequency, *low* consequence) and Risk Class II for the collocated worker (*unlikely* frequency, *moderate* consequence).

For immediate workers (IW) in the RT facility at the time of the fire (with loss of confinement and without controls), the radiological dose consequences are qualitatively judged to be *moderate* due to: (1) the quantity of radiological material that is released due to ***container fissile material loading***, (2) the indicators of a fire (e.g., smoke, flames) that inform the immediate worker of the event, and (3) building ***emergency response*** which directs the immediate worker to evacuate. The IW credited controls to mitigate consequences include the confinement enclosure integrity, and ***emergency response*** (development of a facility-specific emergency plan). These controls tend to lower the non-radiological consequences, as well. The resulting risk class for the scenario is Risk Class III for the immediate worker (*unlikely* frequency, *low* consequence).

Case B: The radiological dose consequences of the unmitigated fire (*e.g.*, ***glovebox automatic sprinkler system*** and ***facility automatic sprinkler system*** not actuated, and ***glovebox filtered exhaust ventilation system*** and confinement area ***filtered exhaust ventilation system*** both fail) are *high* (51 rem) to the MOI @ 1,200 m, *moderate* (18 rem) to the MOI @ 2,367 m, and *high* (2,500 rem) to the CW. The resulting risk class for the unmitigated Case B is Risk Class I for the MOI @ 1,200 m (*anticipated* frequency, *high* consequences), Risk Class I for the MOI @ 2,367 m (*anticipated* frequency, *moderate* consequences) and Risk Class I for the CW (*anticipated* frequency, *high* consequences).

The radiological dose consequences of the mitigated fire (*e.g.*, ***glovebox automatic sprinkler system*** actuates and ***glovebox filtered exhaust ventilation system*** functions, or facility ***automatic sprinkler system*** actuates and confinement area ***filtered exhaust ventilation system*** functions) are *low* to the MOI (5.1E-2 rem @ 1,200 m, 1.8E-2 rem @ 2,367 m) and *moderate* (2.5 rem) to the CW. The resulting risk class for the mitigated Case B is Risk Class III for the MOI (*unlikely* frequency, *low* consequences) and Risk Class II for the CW (*unlikely* frequency, *moderate* consequences).



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For immediate workers (IW) in the RT facility at the time of the fire with loss of confinement and without controls, the radiological dose consequences are qualitatively judged to be *moderate* due to: (1) the quantity radiological material that is released based on the glovebox criticality limit (an attribute of the ***Criticality Safety*** SMP), (2) the indicators of a fire (e.g., smoke, ***fire alarms***, flames) that inform the immediate worker of the event, and (3) building ***emergency response*** which directs the immediate worker to evacuate. The immediate worker credited controls to mitigate consequences include the ***confinement enclosure integrity***, the glovebox criticality limit, ***fire alarm transmittal/Fire Department response*** control, and ***emergency response*** (development of a facility-specific emergency plan). These controls tend to lower the non-radiological consequences, as well. The resulting risk class for the mitigated scenario is Risk Class II for the immediate worker (*unlikely* frequency, *moderate* consequence). The resulting risk class for the unmitigated scenario is Risk Class I for the IW (*anticipated* frequency, *high* consequence).

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 3: Case A
Small LLW Fire in Perma-Con or C-cell
MOI Distance = 1,200 m

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| Default Parameters | | Change Options | | |
|---|---|---|---|---|
| | | Accept Default? | New Value | Value Used |
| Airborne Release Fraction = | 5.0E-02 | Y | | 5.0E-02 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.50E-01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.3E+01 | 4.8E-01 |
| One | 2.3E-02 | 4.8E-04 |
| Two | 4.7E-05 | 9.6E-07 |
| Three | 9.3E-08 | 1.9E-09 |
| Four | 1.9E-10 | 3.9E-12 |

**Fire Scenario 3 - Case A; Radiological Dose Consequences; 1200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 3: Case A
Small LLW Fire in Perma-Con or C-cell
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Change Options | | |
|---|---|---|---|---|
| | | Accept Default? | New Value | Value Used |
| Airborne Release Fraction = | 5.0E-02 | Y | | 5.0E-02 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker χ/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public χ/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.50E-01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.3E+01 | 1.7E-01 |
| One | 2.3E-02 | 1.7E-04 |
| Two | 4.7E-05 | 3.4E-07 |
| Three | 9.3E-08 | 6.9E-10 |
| Four | 1.9E-10 | 1.4E-12 |

**Fire Scenario 3 - Case A; Radiological Dose Consequences, 2367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 3: Case B
Small TRU Waste Fire Inside Glovebox
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | Y | | 5.0E-02 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.60E+01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.5E+03 | 5.1E+01 |
| One | 2.5E+00 | 5.1E-02 |
| Two | 5.0E-03 | 1.0E-04 |
| Three | 1.0E-05 | 2.1E-07 |
| Four | 2.0E-08 | 4.1E-10 |

**Fire Scenario 3 - Case B; Radiological Dose Consequences, 1200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 2 | Fire, Non-lofted |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| SUM | 0.000 |

Describe Scenario:
Fire Scenario 3: Case B
Small TRU Waste Fire Inside Glovebox
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 5.0E-02 | Y | | 5.0E-02 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 1.60E+01

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 2.5E+03 | 1.8E+01 |
| One | 2.5E+00 | 1.8E-02 |
| Two | 5.0E-03 | 3.7E-05 |
| Three | 1.0E-05 | 7.3E-08 |
| Four | 2.0E-08 | 1.5E-10 |

**Fire Scenario 3 - Case B; Radiological Dose Consequences, 2367 m**

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**Table 11-2** Fire Scenario 3, Case A - Small Fire in RT Confinement Enclosure (Non-Glovebox) Involving LLW

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Small fire involving RT confinement enclosure (non-glovebox) contents (1 LLW waste box).<br>Effective MAR = 3.0 grams WG Pu |
| Cause or Energy Source | Energy Sources: 5B (Flammable Gases), 5E (Electrical Power Systems), 13B (Incompatible Chemicals), 13G (Combustibles) |
| Applicable Activity(ies) | RT |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference To TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | 1,200 m<br>High<br>(51 rem)<br>2,367 m<br>Moderate<br>(18 rem) | 1,200 m<br>Low<br>(5.1E-2 rem)<br>2,367 m<br>Low<br>(1.8E-2 rem) | 1,200 m<br>I<br>2,367 m<br>I | 1,200 m<br>III<br>2,367 m<br>III | <u>Container Fissile Material Loading</u><br>Fuel/Combustible Loading<br>Confinement Enclosure Integrity<br>Fire Extinguishers<br>Fire Phones/Fire Department Response | C<br>C<br>C<br>D<br>D | M<br>P<br>P/M<br>P<br>M | AOL 4<br>AOL 8<br>AC 5.4<br>AC 5.4<br>AC 5.4 |
| CW | Anticipated | Unlikely | High<br>(2,500 rem) | Moderate<br>(2.5 rem) | I | II | Same as MOI | | | |
| IW | Anticipated | Unlikely | High | Moderate | I | II | <u>Container Fissile Material Loading</u><br>Confinement Enclosure Integrity<br>Fuel/Combustible Loading<br>Emergency Response<br>Fire Phones/Local Fire Alarm<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>D<br>D<br>D | M<br>M<br>M<br>P<br>M<br>M<br>D | AOL 4<br>AC 5.4<br>AOL 8<br>AC 5.5<br>AC 5.4<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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**Table 11-3** Fire Scenario 3, Case B - Small Fire in Repackaging Confinement Enclosure (Glovebox) Involving TRU Waste

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container) |
| **Accident Type** | Small fire involving RT confinement enclosure contents (TRU waste).<br>Effective MAR = 320 grams WG Pu |
| **Cause or Energy Source** | Energy Sources: 5 B (Flammable Gases), 5E (Electrical Power Systems, 13B (Incompatible Chemicals), 13G (Combustibles) |
| **Applicable Activity(ies)** | RT |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Unlikely | 1,200 m<br>High<br>(51 rem)<br>2,367 m<br>(18 rem) | 1,200 m<br>Low<br>(0.05 rem)<br>2,367 m<br>Low<br>(0.02 rem) | 1,200 m<br>I<br>2,367 m<br>I | 1,200 m<br>III<br>2,367 m<br>III | Confinement Enclosure Integrity<br>Glovebox Criticality Limit<br>Glovebox Fire Suppression System<br>Glovebox Filtered Exhaust Ventilation<br>Automatic Sprinkler System<br>Filtered Exhaust Ventilation (Conf. Area)<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Flow Alarm/Fire Department Response<br>Fire Phones/Fire Department Response | C<br>C<br>C<br>C<br>C<br>C<br>C<br>C<br>D<br>D | P/M<br>M<br>P/M<br>M<br>M<br>M<br>P/M<br>P<br>M<br>M | AC 5.4<br>AC 5.6<br>LCO 3.2<br>LCO 3.4<br>LCO 3.1<br>LCO 3.4<br>AOL 8<br>AOL 8<br>AC 5.4<br>AC 5.4 |
| CW | Anticipated | Unlikely | High<br>(2,500 rem) | Moderate<br>(2.5 rem) | I | II | Same as MOI | | | |
| IW | Anticipated | Unlikely | High | Low | I | III | Confinement Enclosure Integrity<br>Glovebox Criticality Limit<br>Fuel/Combustible Loading<br>Ignition Source Control<br>Emergency Response<br>Fire Phones/Local Fire Alarm<br>Training<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | P/M<br>M<br>P/M<br>P<br>M<br>M<br>M<br>D | AC 5.4<br>AC 5.6<br>AOL 8<br>AOL 8<br>AC 5.5<br>AC 5.4<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

### 11.1.3 Control Set Vulnerability

Three preventive features have been credited in the determination of scenario frequency and eight mitigative features have been credited in the scenario consequence determination.

The credited preventive features are:

1. the hardware control for a ***glovebox fire suppression system*** (Case B: all receptors);
2. the ***fuel/combustible loading and ignition source control*** program (Case A and Case B: all receptors);
3. ***confinement enclosure integrity*** control for Perma-Cons and C-cells (Case A: all receptors); and
4. glovebox integrity as an attribute of the ***maintenance and surveillance of SC-3 SSCs*** (Case B: all receptors).

The credited mitigative features are:

1. glovebox integrity as an attribute of the ***maintenance and surveillance of SC-3 SSCs*** (Case B: IW only);
2. confinement enclosure integrity control (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) for Perma-Cons and C-cells (Case A: all receptors);
3. the ***container fissile material loading*** control (Case A: all receptors);
4. the glovebox criticality limit (an attribute of the ***Criticality Safety*** SMP) (Case B: all receptors);
5. the hardware control for a ***glovebox filtered exhaust ventilation system*** (Case B: all receptors);
6. the hardware control for a ***glovebox fire suppression system*** (Case B: all receptors);
7. the hardware control for a confinement area ***filtered exhaust ventilation system*** (Case B: CW and MOI receptors);
8. the hardware control for a facility ***automatic sprinkler system*** (Case B: CW and MOI receptors);
9. the ***emergency response*** control (Case A and Case B: IW only); and
10. the ***fuel/combustible loading and ignition source control*** program (Case B: IW).

Failure of the ***glovebox fire suppression system*** preventive feature (Case B) increases the likelihood that the fire would propagate through the glovebox and involve all of the contents. If the fire is extinguished before involving all of the glovebox contents, less MAR is involved in the fire and results in a corresponding decrease in the radiological dose consequences.

Failure of the ***fuel/combustible loading and ignition source control*** preventive feature can increase the likelihood (to *anticipated*) that a fire can be ignited and sustained. The likelihood of a fire starting in a waste storage area is considered *unlikely* if these controls are implemented.

Failure of the confinement enclosure integrity (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) feature, credited as both preventive and mitigative, increases the likelihood that the fire will breach the Perma-Con or C-cell and impact nearby waste containers. Without this feature, it is *anticipated* the fire would breach the the Perma-Con or C-cell enclosure.

Failure of the glovebox integrity preventive feature (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) increases the likelihood that the fire will breach the glovebox and impact nearby waste containers. Without this feature, it is *anticipated* the fire would breach the glovebox enclosure.

Failure of the glovebox integrity mitigative feature (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) can result in the fire breaching the glovebox resulting in increased radiological consequences to all receptors.

Failure of the ***container fissile material loading*** mitigative feature can result in additional MAR being involved in Case A and a corresponding increase in the radiological dose consequences to all receptors.

Failure of the glovebox criticality limit mitigative feature (an attribute of the ***Criticality Safety*** SMP) can result in the introduction of additional MAR into the glovebox in Case B with a corresponding increase in the radiological dose consequences to all receptors.

Failure of the ***glovebox filtered exhaust ventilation system*** mitigative feature credited in Case B can result in increased radiological dose consequences to all receptors. This system is credited as a Safety SSC to maintain the low doses to the MOI.

Failure of the ***glovebox fire suppression system*** mitigative feature (Case B) can result in additional MAR being involved in the fire and a corresponding increase in the radiological dose consequences. This system is credited as a Safety SSC to maintain the low doses to the MOI.

Failure of the confinement area ***filtered exhaust ventilation system*** mitigative feature credited in Case B can result in increased radiological dose consequences to all receptors. This system is credited as a Safety SSC to maintain the low doses to the MOI.

Failure of the facility ***automatic sprinkler system*** mitigative feature credited in Case B can result in additional MAR being involved in the fire and a corresponding increase in the radiological dose consequences. This system is credited as a Safety SSC to maintain the low doses to the MOI.

Failure of the ***fuel/combustible loading control*** mitigative feature (Case A and Case B) can result in additional MAR being involved in the fire and a corresponding increase in the radiological dose consequences.

Failure of the ***emergency response*** mitigative features (*i.e.*, inadequate emergency plan) can result in additional IW exposure to airborne radioactive materials. The IW scenario consequences may increase to *moderate* for this event due to the higher consequences associated with the longer exposure duration.

In the situations discussed above, the following defense-in-depth features tend to mitigate or prevent the scenario but are not credited in the analysis:

- ***Fire Phones/Local Fire Alarm*** (IW only): ***Fire phone*** use activates ***local fire alarms*** and can reduce IW consequences by providing indication of a fire to facility personnel. Facility management may be informed by various alarms or personnel may be aware of the fire and use the ***fire phone***.
- ***Flow Alarm/Fire Department Response*** (Case B: MOI and CW): For fires in areas covered by the ***automatic sprinkler system, flow alarm*** transmittal to the Fire Dispatch Center can lead to scenario mitigation due to ***Fire Department response***.
- ***Fire Phones/Fire Department Response*** (MOI and CW): ***Fire phone*** communication to the Fire Dispatch Center can lead to scenario mitigation due to ***Fire Department response***.
- ***Fire Extinguishers*** (MOI and CW): ***Fire Extinguishers*** are located throughout waste storage areas and are well maintained as required by the ***Fire Protection*** SMP. Use of fire extinguishers by facility personnel can mitigate the scenario by extinguishing the fire before loss of confinement occurs. Although personnel do not receive hands-on portable fire extinguisher training, general training concerning fire extinguisher use is provided during the General Employee Training.
- ***Training*** (IW only): The IW ***training*** program is an additional mitigative feature that can reduce IW consequences as a reinforcement of ***emergency response*** evacuation guidance.
- ***LS/DW*** (IW only): Facility management or other personnel can utilize the ***LS/DW system*** to reduce IW consequences by announcing the spill to facility personnel.

### 11.1.4 Fire Scenario Assumptions

In the evaluation of the above fire scenarios, assumptions are identified for prevention and/or mitigation of the accidents. Table 11-4 presents a listing of the assumptions specified in the evaluation of fire scenarios. The scenarios to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 11-4** Fire Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| LLW containers contain no more than 0.5 grams WG Pu equivalent in drums and 3 grams WG Pu equivalent in metal boxes. | Fire Scenario 3, Case A | Sets the potential MAR for the scenario impacting LLW containers.<br>***Container Fissile Material Loading*** |
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs. | Fire Scenario 3, Case B | Sets the potential MAR for scenarios impacting TRU waste containers.<br>***Container Fissile Material Loading*** |
| Glovebox enclosures contain no more than 320 grams WG Pu equivalent. | Fire Scenario 3, Case B | Sets the glovebox maximum MAR.<br>***Criticality Safety (Criticality Limit)*** |
| Fire extinguishers are available and maintained to allow personnel fire suppression actions. | Fire Scenario 3 | Reduces the consequences of fire growth<br>***Fire Extinguishers*** |
| Fires ignited in open TRU waste containers inside a glovebox will be mitigated by HEPA filtration. | Fire Scenario 3, Case B | Reduces the consequences to all receptors.<br>***Filtered Exhaust Ventilation System*** |
| Gloveboxes will have an operable fire suppression system. | Fire Scenario 3, Case B | Reduces the consequences of fire growth within the glovebox.<br>***Glovebox Fire Suppression System*** |
| Automatic sprinkler systems are located in all TRU waste confinement areas. | Fire Scenario 3, Case B | Reduces the consequences of fire growth within the confinement area.<br>***Automatic Sprinkler System*** |
| Glovebox integrity will limit propagation of a TRU/TRM waste fire. | Fire Scenario 3, Case B | Reduces the exposure to the IW, CW and MOI from releases.<br>***Maintenance and Surveillance of SC-3 SSCs (Glovebox Integrity)*** |
| Perma-Con and C-cell integrity will limit propagation of a LLW waste fire. | Fire Scenario 3, Case A | Reduces the exposure to the CW and MOI from releases.<br>***Maintenance and Surveillance of SC-3 SSCs (Glovebox Integrity)*** |
| A combustible material and ignition source control program shall be implemented to make fires in areas containing staged or stored radioactive material *unlikely* events. | Fire Scenario 3 | Reduces the likelihood of facility fires potentially impacting radioactive material to *Unlikely*.<br>***Fuel/Combustible Loading and Ignition Source Control*** |



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**Table 11-4** Fire Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| Attributes of combustible material control include:<br>• high heat release rate combustible material restrictions;<br>• no wooden crates in internal waste storage areas;<br>• combustibles have five-foot separation from waste containers<br>Attributes of ignition source control include:<br>• restrictions on smoking in facilities;<br>• hot work permits | | |
| The Waste Management Facilities will develop facility-specific Emergency Plans. | Waste Repackaging Fire Scenario 1, Cases A & B | Reduces the exposure to the IW from releases.<br>***Emergency Response*** |



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## 11.2 SPILL SCENARIOS

### 11.2.1 Spill Scenario Development and Selection

Waste staging, storage, and handling activities are conducted to support RT activities. Representative accident scenarios associated with such activities are presented in Section 8, *Storage and Handling (SH) Accident Analysis*, and are not duplicated in this section.

Waste repackaging involves opening either LLW or TRU waste containers, sorting the contents, and repackaging the contents into appropriate waste containers. However, treatment activities are limit to LLW. Site Closure planning does not currently include onsite treatment of TRM waste. LLW containers are usually opened inside a confinement enclosure such as a Perma-Con or contamination C-cell. In fact, when the level of radioactivity is determined to be sufficiently low, LLW containers may be opened outside of a confinement enclosure. TRU waste containers are only opened inside a HEPA-filtered confinement enclosure located in a confinement area. Confinement areas are equipped with HEPA filtration (***filtered exhaust ventilation system***) and are covered by a facility ***automatic sprinkler system***.

Several types of spills are postulated to occur: (1) spills involving LLW in confinement enclosures without credited HEPA ventilation (e.g., Perma-Cons, C-cells), (2) spills involving TRU waste inside a confinement enclosure (glovebox) equipped with ***glovebox filtered exhaust ventilation system***, and (3) spills involving TRU waste outside a glovebox but inside a confinement area (*e.g.*, areas with ***filtered exhaust ventilation system***).

Plastic materials are used as part of repackaging activities (*e.g.*, waste bags, glovebags, etc.). Bagged waste in a Perma-Con or C-cell can be breached by operator error (*e.g.*, puncture, drop, fall, etc.) during repackaging activities. Glovebags are used to contain waste during transition into and out of gloveboxes. A glovebag can be breached during transition of the waste into or out of a glovebox due to an impact or puncture from material handling equipment (*e.g.*, forklift, drum lifter, etc.) or by operator error (drop or fall) while handling the glovebag.

Confinement enclosures can be damaged and breached by external and internal initiators. External damage to confinement enclosures can occur due to (1) puncture by a compressed gas cylinder sent airborne because the valve is accidentally sheared off; (2) impact from overhead equipment or structure during a seismic event; or (3) overpressure from an external explosion of a flammable gas/oxygen mixture. Internal damage to confinement enclosures can occur due to suspended loads/materials forcibly contacting a confinement structure wall from inside the enclosure. These same events that can breach a confinement enclosure can also breach bagged waste attached to or near a confinement enclosure.

#### 11.2.1.1 Breach of Bagged Waste

Bagged waste in a Perma-Con or C-cell can be breached due to operator error (*e.g.*, puncture, drop, fall, etc.) while handling the waste (*Hazard/Energy Source 7C*). A glovebag is external to a glovebox and can be breached due to an impact and/or puncture from material handling equipment such as a forklift or drum lifter (*Hazard/Energy Source 7A*). Two cases are considered for this scenario. Case A involves a breach of bagged LLW inside a Perma Con or C-cell. Case B involves a breach of a glovebag containing TRU waste outside of a glovebox, but inside a confinement area. In both cases it is conservatively assumed that the entire contents of the bagged waste is involved and subject to release. This spill scenario is *anticipated* and is evaluated further as the representative RT spill scenario.

### 11.2.1.2 Breach of Confinement Enclosure by Airborne Compressed Gas Cylinder

A confinement enclosure or glovebag can be breached by a compressed gas cylinder missile (*Hazard/Energy Source 6C*). If a cylinder valve were accidentally sheared off during cylinder handling (changeout), the cylinder would become an airborne missile that could impact and puncture a confinement enclosure or bagged waste. This external impact results in release of the entire contents of the confinement enclosure or glovebag. This spill scenario is *unlikely*. The Breach of Bagged Waste scenario (Section 11.2.1.1) involves the same amount of MAR and has a higher occurrence frequency. Therefore, this spill scenario is not evaluated further.

### 11.2.1.3 Breach of Confinement Enclosure by Falling Overhead Equipment/Structural Debris

A confinement enclosure or glovebag can be breached by falling overhead equipment or building structure debris (*Hazard/Energy Source 8A*) during a seismic event (*Hazard/Energy Source 13H*). This external impact is *unlikely* and results in release of the entire contents of the confinement enclosure or glovebag. The Breach of Bagged Waste scenario (Section 11.2.1.1) involves the same amount of MAR and has a higher occurrence frequency. Therefore, this spill scenario is not evaluated further.

### 11.2.1.4 Breach of Confinement Enclosure by External Explosion

A confinement enclosure or glovebag can be breached by an external explosion of a flammable gas/oxygen mixture (*Hazard/Energy Source 5B*). This external impact is *unlikely* and results in release of the entire contents of the confinement enclosure or glovebag. The Breach of Bagged Waste scenario (Section 11.2.1.1) involves the same amount of MAR and has a higher occurrence frequency. Therefore, this spill scenario is not evaluated further.

### 11.2.1.5 Breach of Confinement Enclosure by Suspended Loads

A confinement enclosure or glovebag can be breached by suspended loads/materials (*Hazard/Energy Sources 7C and 8A*) forcibly contacting a confinement structure wall or bagged waste from inside the enclosure. This internal impact is *unlikely* and results in release of the entire contents of the confinement enclosure or glovebag. The Breach of Bagged Waste scenario (Section 11.2.1.1) involves the same amount of MAR and has a higher occurrence frequency. Therefore, this spill scenario is not evaluated further.

### 11.2.1.6 Representative Spill Scenario

The representative spill scenario evaluated for waste management facility RT is:

- Spill Scenario 4 – Breach of Bagged Waste

### 11.2.2 Spill Scenario 4 - Breach of Bagged Waste

This accident scenario is discussed below and is summarized in Tables 11-5 and 11-6. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

Bagged waste in a Perma-Con or C-cell can be breached (by drop or fall) due to operator error while handling the waste (*Hazard/Energy Source 7C*). A glovebag is external to a glovebox and can be breached due to an impact and/or puncture from material handling equipment such as a forklift or drum lifter (*Hazard/Energy Source 7A*). Two cases are evaluated for this scenario. Case A involves a breach of bagged LLW inside a Perma-Con or C-cell. Case B involves a breach of a glovebag containing TRU waste outside of a glovebox, but inside a confinement area. In both cases it is assumed that the entire contents of the bagged waste is involved and subject to release. This spill scenario is *anticipated* without prevention.

Case A involves a breach of bagged LLW inside a Perma-Con or C-cell that does not have filtered exhaust ventilation (HEPA filtration). Case B involves a breach of a glovebag containing TRU waste outside of a glovebox, but inside a confinement area that has a ***filtered exhaust ventilation system***.

A non-lofted plume of unconfined radioactive material is assumed and the spill is analyzed as a short duration, 10 minute release.

*Scenario Modeling Assumptions*: spill; unconfined material; 10-minute duration.

Accident Frequency

The scenario frequency is *anticipated* because accidents involving material handling equipment and operator error have occurred at the Site in the past.

*Scenario Modeling Assumptions*: *anticipated* event

Material-at-Risk

Case A: It is assumed that the entire contents of bagged LLW is involved in the spill and is subject to release (DR = 1). Waste packaging requirements allow up to 3 grams WG Pu equivalent to be contained in each LLW box, equivalent to the quantities assumed in the bagged waste. An administrative control for ***container fissile material loading*** is credited for limiting the bagged waste contents to a maximum of 3.0 grams of WG Pu. Therefore, the total effective MAR for the postulated scenario, assumed to be the waste from one LLW box, is 3.0 grams of WG Pu. The material is assumed to be aged WG Pu and Solubility Class W. A leakpath factor (LPF) of 0.1 is applied (Ref. 9), crediting the confinement enclosure integrity (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) of the Perma-Con or C-cell. Note that if a confinement enclosure with less structural strength is used, this leakpath factor would not apply.

Case B: It is assumed that the entire contents of a glovebag containing TRU waste is involved in the spill and is subject to release (DR = 1). The confinement enclosure criticality limit, which is an attribute of the ***Criticality Safety*** SMP, is credited for limiting the contents of the glovebox to a maximum of 320 grams of WG Pu. Therefore, the total effective MAR for the postulated scenario is 320 grams of WG Pu. The material is assumed to be aged WG Pu and Solubility Class W. A LPF of 0.001 is applied crediting confinement area HEPA filtration (***filtered exhaust ventilation system***).

*Scenario Modeling Assumptions*:

Case A: aged WG Pu; 3.0 grams; Solubility Class W DCF; LPF = 0.1; DR = 1.0.

Case B: aged WG Pu; 320 grams; Solubility Class W DCF; LPF = 0.001; DR = 1.0.

Accident Consequences

Case A: The radiological dose consequences of a spill involving the entire contents of a bagged LLW waste inside a Perma-Con or C-cell are *low* (9.6E-4 rem) to the MOI at 1,200 meters, *low* (3.4E-4 rem) to the MOI at 2,367 meters, and *low* (4.7E-2 rem) to the CW. The resulting risk class for the scenario is Risk Class III for the MOI at 1,200 m and 2,367 m (*anticipated* frequency, *low* consequence), and Risk Class III for the CW (*anticipated* frequency, *low* consequence). HEPA ventilation is not credited for reducing the dose consequences in this scenario.

For the IW in the RT facility at the time of the spill, the radiological dose consequences are qualitatively judged to be *low* due to: (1) the limited amount of radiological material that is released; (2) the indicators of a spill (*e.g.*, noise) that inform the IW of the event, and (3) building ***emergency response*** that directs the IW to evacuate. The resulting risk class for the scenario is Risk Class III for the IW (*anticipated* frequency, *low* consequence).

Case B: The radiological dose consequences of a spill involving the entire contents of a glovebag containing TRU waste in a confinement area are *low* (1E-3 rem) to the MOI at 1,200 meters, *low* (3.7E-4 rem) to the MOI at 2,367 meters, and *low* (5E-2 rem) to the CW. The resulting risk class for the scenario is Risk Class III for the MOI at 1,200 m and 2,367 m (*anticipated* frequency, *low* consequence), and Risk Class III for the CW (*anticipated* frequency, *low* consequence). HEPA ventilation (***filtered exhaust ventilation system)*** is credited for reducing the dose consequences in this scenario.

For the IW in the RT facility at the time of the spill, the radiological dose consequences are qualitatively judged to be *low* due to: (1) the limited amount of radiological material that is released crediting the glovebox criticality limit, which is an attribute of the ***Criticality Safety*** SMP; (2) the indicators of a spill (*e.g.*, noise) that inform the IW of the event, and (3) building ***emergency response*** that directs the IW to evacuate. The resulting risk class for the scenario is Risk Class III for the IW (*anticipated* frequency, *low* consequence).



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E-01 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 4: Case A
Breach of Bagged LLW in Perma-Con or C-Cell
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E-01 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 9.6E-04 |
| One | 4.7E-05 | 9.6E-07 |
| Two | 9.3E-08 | 1.9E-09 |
| Three | 1.9E-10 | 3.9E-12 |
| Four | 3.7E-13 | 7.7E-15 |

Respirable Initial Source Term (g) = 3.00E-03

**Spill Scenario 4, Case A, LLW Spill, 1200m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.00E+00 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E-01 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:
Spill Scenario 4: Case A
Breach of Bagged LLW in Perma-Con or C-Cell
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | | Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 | Y | | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | Y | | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.00E+00 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E-01 | | | |

RESULTS

| Number of HEPA Stages | Plume Doses CW (rem) | Plume Doses MOI (rem) |
|---|---|---|
| Zero | 4.7E-02 | 3.4E-04 |
| One | 4.7E-05 | 3.4E-07 |
| Two | 9.3E-08 | 6.9E-10 |
| Three | 1.9E-10 | 1.4E-12 |
| Four | 3.7E-13 | 2.7E-15 |

Respirable Initial Source Term (g) = 3.00E-03

**Spill Scenario 4, Case A, LLW Spill, 2367m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Spill Scenario 4: Case B
Breach of Glovebag Containing TRU Waste
MOI Distance = 1,200 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+02 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 2.05E-04 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 3.20E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 5.0E+01 | 1.0E+00 |
| One | 5.0E-02 | 1.0E-03 |
| Two | 1.0E-04 | 2.1E-06 |
| Three | 2.0E-07 | 4.1E-09 |
| Four | 4.0E-10 | 8.2E-12 |

**Spill Scenario 4, Case B, TRU Waste Spill, 1200m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| χ/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 3 | Uncon Combust |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 1.000 | |
| Material at Risk (g) = | 3.20E+02 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Spill Scenario 4: Case B
Breach of Glovebag Containing TRU Waste
MOI Distance = 2,367 m

Version 1.2

| Default Parameters | |
|---|---|
| Airborne Release Fraction = | 1.0E-03 |
| Respirable Fraction = | 1.0E+00 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 |
| Effective MAR, Including DR (g) = | 3.20E+02 |
| Plume Expansion Factor = | 1.000 |
| Collocated Worker χ/Q ($s/m^3$) = | 9.94E-03 |
| Public χ/Q ($s/m^3$) = | 7.30E-05 |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 |

Respirable Initial Source Term (g) = 3.20E-01

| Change Options | | |
|---|---|---|
| Accept Default? | New Value | Value Used |
| Y | | 1.0E-03 |
| Y | | 1.0E+00 |
| Y | | 3.6E-04 |
| Y | | 4.35E+07 |

RESULTS

| Number of HEPA Stages | Plume Doses | |
|---|---|---|
| | CW (rem) | MOI (rem) |
| Zero | 5.0E+01 | 3.7E-01 |
| One | 5.0E-02 | 3.7E-04 |
| Two | 1.0E-04 | 7.3E-07 |
| Three | 2.0E-07 | 1.5E-09 |
| Four | 4.0E-10 | 2.9E-12 |

**Spill Scenario 4, Case B, TRU Waste Spill, 2367m**

**Table 11-5** Spill Scenario 4, Case A, LLW Waste Spill

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Spill involving LLW; spill due to operator error (drop or fall) while handling the bagged waste during repackaging activities. Accident occurs inside Perma-Con or C-cell. Effective MAR = 3 grams of aged WG Pu |
| Cause or Energy Source | Energy Sources: 7C, *(Suspended Loads/Materials[kinetic energy])* |
| Applicable Activity(ies) | RT |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Anticipated | Not Applicable | @ 1,200 m<br>Low<br>(9.6E-4 rem)<br>@ 2,367 m<br>Low<br>(3.4E-4 rem) | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>III | Confinement Enclosure Integrity<br>Container Fissile Material Loading<br>Training | C<br>C<br>D | M<br>M<br>P | AC 5.4<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Anticipated | Not Applicable | Low<br>(4.7E-2 rem) | Not Applicable | III | Same as MOI | | | |
| IW | Anticipated | Anticipated | Not Applicable | Low | Not Applicable | III | Confinement Enclosure Integrity<br>Container Fissile Material Loading<br>Emergency Response<br>Training<br>LS/DW | C<br>C<br>C<br>D<br>D | M<br>M<br>M<br>P/M<br>M | AC 5.4<br>AOL 4<br>AC 5.5<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 11-6 Spill Scenario 4, Case B, TRU Waste Spill

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container) |
| Accident Type | Spill involving TRU waste; spill due to impact/puncture of glovebag by material handling equipment or by operator error (drop or fall) while handling the glovebag during repackaging activities. Accident occurs outside glovebox, but inside confinement area.<br>Effective MAR = 320 grams of aged WG Pu. Mitigated = One Stage of HEPA filtration; Unmitigated = No HEPA filtration |
| Cause or Energy Source | Energy Sources: 7A *(Vehicles, Material Handling Equipment)*, and 7C *(Suspended Loads/Materials[kinetic energy])* |
| Applicable Activity(ies) | RT |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Anticipated | @ 1,200 m<br>Moderate (1.0 rem)<br>@ 2,367 m<br>Moderate (0.37 rem) | @ 1,200 m<br>Low (1.0E-3rem)<br>@ 2,367 m<br>Low (3.7E-4 rem) | @ 1,200 m<br>I<br>@ 2,367 m<br>I | @ 1,200 m<br>III<br>@ 2,367 m<br>II I | Glovebox Criticality Limit<br>Filtered Exhaust Ventilation (Conf. Area)<br>Training | C<br>C<br>D | M<br>M<br>P | AC 5.6<br>LCO 3.4<br>AC 5.6 |
| CW | Anticipated | Anticipated | High (50 rem) | Low (5.0E-2 rem) | I | III | Same as MOI | | | |
| IW | Anticipated | Anticipated | High | Low | I | III | Glovebox Criticality Limit<br>Emergency Response<br>Training<br>LS/DW | C<br>C<br>D<br>D | M<br>M<br>M<br>M | AC 5.6<br>AC 5.5<br>AC 5.6<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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### 11.2.3 Control Set Vulnerability

No preventive features have been credited in the determination of scenario frequency and five mitigative features have been credited in the scenario consequence determination.

The credited preventive features are:

1. the confinement enclosure integrity (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) control which allows application of a 0.1 LPF for Perma-Cons and C-Cells (Case A: all receptors);
2. the ***filtered exhaust ventilation system*** control (Case B: CW and MOI receptors)
3. the ***container fissile material loading*** administrative control which limits the contents of the bagged waste to 3 grams WG Pu equivalent (Case A: all receptors);
4. the glovebox criticality limit (an attribute of the ***Criticality Safety*** SMP) which limits the contents of a glovebox to 320 g WG Pu equivalent; (Case B: all receptors) and.
5. the ***emergency response*** control (Case A and Case B: IW receptors).

Failure of the confinement enclosure integrity (an attribute of the ***maintenance and surveillance of SC-3 SSCs*** administrative control) (Case A only) mitigative feature would increase the leakpath factor to 1.0 and result in higher radiological consequences to all receptors.

Failure of the ***filtered exhaust ventilation system*** mitigative feature (Case B only) would result in increased radiological dose consequences to the CW and MOI. The ***filtered exhaust ventilation system*** is credited as a Safety SSC to maintain the low doses to the MOI.

Failure of the ***container fissile material loading*** mitigative feature (underestimation of existing container inventory) would result in additional MAR and a corresponding increase in radiological dose consequences to all receptors.

For Case B, failure of the credited glovebox criticality limit (an attribute of the ***Criticality Safety*** SMP) would result in the introduction of additional MAR into the glovebox and a corresponding increase in the radiological dose consequences to all receptors.

Failure of the ***emergency response*** mitigative features (*i.e.*, inadequate emergency plan) could result in additional IW exposure to airborne radioactive materials. The IW scenario consequences may increase to *moderate* for this event due to the higher consequences associated with the longer duration exposure.

In the situations discussed above, the following defense-in-depth features tend to mitigate or prevent the scenario but are not credited in the analysis:

- ***Training*** (CW and MOI): Operator repackaging training and material handling equipment training are preventive features that can reduce the probability that the accident occurs.

- ***Training*** (IW only): The IW ***training*** program is an additional mitigative feature that can reduce the IW consequences as a reinforcement of ***emergency response*** evacuation guidance.

### 11.2.4 Spill Scenario Assumptions

In the evaluation of the above spill scenarios, assumptions were identified for prevention and/or mitigation of the accidents. Table 11-7 presents a listing of the assumptions specified in the evaluation of spill scenarios. The scenarios to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 11-7** Spill Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| LLW containers contain no more than 0.5 grams WG Pu equivalent in drums and 3 grams WG Pu equivalent in metal boxes. | Spill Scenario 4, Case A | Sets the potential MAR for the scenario impacting bagged LLW.<br>***Container Fissile Material Loading*** |
| Glovebox enclosures contain no more than 320 grams WG Pu equivalent. | Spill Scenario 4, Case B | Sets the potential MAR for the scenario impacting TRU waste.<br>***Criticality Safety (Criticality Limit)*** |
| Spills inside a Perma-Con or C-cell will be mitigated by the enclosure structure. | Spill Scenario 4, Case A | Reduces the dose to CW and MOI by reducing leakpath factor to 0.1.<br>***Maintenance and Surveillance of SC-3 SSCs (Confinement Enclosure Integrity)*** |
| Spills outside of glovebox confinement enclosure will be mitigated by confinement area HEPA filtration | Spill Scenario 4, Case B | Reduces the dose to CW and MOI.<br>***Filtered Exhaust Ventilation System*** |
| The Waste Management Facilities will develop facility-specific Emergency Plans. | Spill Scenario 4, Cases A & B | Reduces the exposure to the IW from releases.<br>***Emergency Response*** |

# 12. WASTE GENERATION (GN) ACCIDENT ANALYSIS

This section presents the accident analysis for the following fire, spill, and explosion accident scenarios associated with GN activities as identified in Section 6.2.5, *Waste Generation (WG) Accident Scenarios.*

***Reserved***

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# 13. ROUTINE ACTIVITIES (RA) ACCIDENT ANALYSIS

This section presents the accident analysis for the following fire and explosion scenarios associated with RA as identified in Section 6.2.6, *Routine Activities (RA) Accident Scenarios,* and Table 6-4:

Fire:

- Container (direct flame impingement)

Explosion:

- Facility

## 13.1 FIRE SCENARIO ACCIDENT ANALYSIS

### 13.1.1 Fire Scenario Development and Selection

Waste management facility personnel may use propane or other flammable gas torches (*Hazard/Energy Source 5B*) in support of construction and maintenance activities. This type of equipment has the potential to directly impact Type B shipping containers (*Hazard/Energy Source 4A*) or waste containers (*Hazard/Energy Source 4B*) located in a waste management facility. Credited protective features identified in the discussion that follows will be indicated in ***bold italicized*** text.

#### 13.1.1.1 Container Fire: Direct Flame Impingement

Type B shipping containers were eliminated from further consideration in this analysis because they are stored in vaults and ***flammable gas use*** controls restrict the use of propane or other flammable gases in vaults while SNM is present. A radiological release due to direct flame impingement on a LLW or TRU waste container is bounded by the 1 MW and 4 MW facility fires analyzed in Sections 8.1.2 and 8.1.3. The facility fires are bounding because (1) one or more containers are postulated to be impacted whereas direct flame impingement will only impact a single container, and (2) hot work control (an attribute of the ***fuel/combustible loading and ignition source control*** program) requirements assure that direct flame impingement is an *extremely unlikely* event.

The only remaining container of interest for this scenario is the POC. It is postulated that a flammable gas device is being used in the same room that stores POCs. The containers are separated from the work area per guidance from industrial safety and the Fire Department. It is possible that a worker could fall off a ladder or suffer some ailment that results in the flammable gas device being dropped in the direction of the stored containers. Portable propane gas cylinders may be able to roll toward waste containers. Oxyacetylene torches are not likely to roll but could fall near waste containers.

In the case of a POC, a pipe component is located inside a 55-gallon drum. Propane torches are most likely to come in contact with containers due to the possibility of their rolling when dropped. However, propane torches are *unlikely* to breach even the outer container due to



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the relatively low temperature associated with the torch in combination with the significant heat sink available in the drum. Subsequent breaching of the pipe component is considered to be *incredible*. The combination of hot work control requirements and the *unlikely* breach of the container by a propane torch assumption leads to a *beyond extremely unlikely* event, which is not further evaluated.

Oxyacetylene torches or other relatively high temperature torches would breach the outer container of a POC if they came in contact with the container. For the torch flame to be aligned in a manner to breach the outer container and then act on the pipe component in a manner leading to breach of the pipe is considered to be an *unlikely* if not *extremely unlikely* event without intentional directing of the torch flame. The combination of hot work control requirements and the *unlikely* to *extremely unlikely* breach of both the outer and inner containers by a high temperature leads to a *beyond extremely unlikely* event. Therefore, no credible facility fire scenarios are postulated dealing with direct flame impingement on waste containers.

### 13.1.1.2 Representative Fire Scenario

No direct flame impingement fire scenarios involving waste containers are further evaluated.

## 13.2 EXPLOSION SCENARIO ACCIDENT ANALYSIS

### 13.2.1 Explosion Scenario Development and Selection

The analyzed explosion scenario is an external explosion impacting multiple waste containers due to a localized deflagration of a flammable gas (*e.g.*, acetylene, propane, etc.). The MAR values associated with the container types evaluated in the explosion scenarios is presented in Table 13-1.

**Table 13-1** Explosion Scenario MAR Values

| CONTAINER TYPE | CONTAINER CONFIGURATION | MAR (WG Pu equivalent per involved container) |
|---|---|---|
| Metal LLW box | multiple | 3 grams |
| LLW drum | multiple | 0.5 grams |
| LLW drum (95th % UCL value plus conservatism) | multiple | 0.24 grams |
| TRUPACT II SWB or metal waste box | multiple | 320 grams |
| TRU drum | multiple | 200 grams |
| TRU drum (95th % UCL value plus conservatism) | multiple | 114 grams |

#### 13.2.1.1 <u>External Explosion: Waste Container Storage Area Explosion</u>

The hazards initially identified in the hazard identification and evaluation process dealt with natural gas, propane, and acetylene (*Hazard/Energy Source 5B*). Explosions initiated by large natural gas sources or a propane source (*e.g.*, a propane tank farm) are considered to be facility-specific based on the proximity to the source(s) and are addressed in individual facility AB documents. Smaller sources, specifically propane and acetylene gas cylinders used for welding, cutting, and brazing, are evaluated in this NSTR. Because acetylene gas has a higher explosive yield than propane and is more commonly used in waste management facilities, the external explosion scenario is assumed to involve acetylene.

For explosions involving acetylene gas, transition from a deflagration explosion to a detonation explosion depends on the flammable gas mixture, temperature and pressure, size of the enclosed room, and the ignition source. With a powerful ignition source, detonation may occur upon ignition, even in the open. However, explosions of gases (both lighter- and heavier-than-air) and liquid vapors are nearly always deflagrations and are seldom detonations (Ref. 2 and 56). Detonation explosions of fuel/air mixtures can potentially occur under the following restrictive conditions: (1) the fuel/air vapor cloud must nearly fill, or be confined by, the closed volume it occupies; (2) the fuel/air mixture must have a concentration within the detonable range; and (3) a highly energetic ignition source must initiate the explosion (Ref. 57). The ignition energy required to initiate a detonation is usually many orders of magnitude greater than that required to initiate a deflagration (Ref. 58). For acetylene, the minimum ignition energy to ignite a detonation is 5.3 kJ (propane ignition energy is 210 kJ). An electric arc in a shorted 50-to-75 horsepower motor may be sufficient to ignite an acetylene detonation. For waste management facilities, it is assumed that such an ignition source may be present; however, the remaining two conditions must still be met in order to have a detonation. For the situations of concern within a facility, the most likely mode of combustion of a fuel/air mixture is a deflagration.

Combustion of acetylene, whether it is a deflagration or detonation, can occur only when the concentration is within the flammable range, which is between 2.5% and 81% by volume. Acetylene cylinders come in various sizes up to 300 $ft^3$. Assuming that one cylinder or 300 $ft^3$ of gas is released and mixed uniformly with an entire room volume, the maximum room size that would result in an acetylene gas concentration exceeding the lower explosive limit of 2.5% is 12,000 $ft^3$ (300 $ft^3 \div 0.025$). An acetylene gas explosion inside a waste storage area room with an enclosed volume of 12,000 $ft^3$ or less can result in a confined deflagration rather than an unconfined deflagration. A confined deflagration will result in a greater maximum overpressure condition that can potentially result in container failure. To prevent a confined deflagration from occurring, the use of flammable gases in waste storage areas smaller than 12,000 $ft^3$ is prohibited as part of the ***flammable gas use*** administrative control. Crediting the ***flammable gas use*** administrative control, flammable gas explosions in waste storage areas less than 12,000 $ft^3$ are not further evaluated. Individual facility AB documents will identify specific rooms that are affected by the ***flammable gas use*** administrative control.

In waste storage areas greater than 12,000 $ft^3$, the combustion process will be limited to a localized air/acetylene mixture within the flammable range. It is reasonable to model explosions in larger rooms as unconfined deflagrations based on the largest volume of a flammable air/acetylene mixture being approximately 12,000 $ft^3$ (based on the lower flammability limit and 300 $ft^3$ of acetylene). When a volume of gas or vapor in air deflagrates in an unconfined space, only a small fraction of the energy in the cloud actually contributes to any resultant damage (Ref. 59). This fraction is referred to as the yield factor.

Table 13-1 shows the estimated effective MAR values for waste containers that may be involved in this scenario. These MAR values are used to determine which container types to evaluate further in Section 13.2.2 as the representative explosion scenario for RA.

#### **13.2.1.2** Representative Explosion Scenario

The representative explosion scenario evaluated for waste management facility RA is:

- Explosion Scenario 2 – External Explosion in Waste Storage Area



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### 13.2.2 Explosion Scenario 2 – External Explosion in Waste Storage Area

This accident scenario is discussed below and is summarized in Tables 13-4 and 13-5. Credited protective features identified in the discussions that follow will be indicated in ***bold italicized*** text. The RADIDOSE calculations for this scenario are provided after the *Accident Consequences* section.

Accident Scenario

It is postulated that a full 150 $ft^3$ acetylene cylinder ruptures releasing its entire contents into a waste storage area (room) that has a volume greater than 12,000 $ft^3$. A release from a 150 $ft^3$ acetylene cylinder is postulated based on previous analyses performed for the Building 371/374 Complex, which are discussed in subsequent paragraphs. A release of acetylene gas can occur as a result of cylinder failure (*e.g.*, manufacturing deficiency), damage to the gas cylinder (*e.g.*, toppling/dropping of cylinder, kinetic energy, puncture), or damage to ancillary equipment (*i.e.*, cylinder valve, regulator, relief device, hoses, torch, *etc.*) during construction or maintenance activities.

Following the release, it is assumed that the gas mixes with room air to form a localized, flammable air/gas mixture. The flammable air/gas mixture only lasts for a limited period of time due to continued mixing. While the flammable mixture is present, it is postulated that an ignition source (*e.g.*, electric power system, *Hazard/Energy Source 5E*) ignites the acetylene to produce a unconfined deflagration within the room. The MAR for this analysis is the entire radiological inventory in the waste container storage room where the explosion occurs, packaged as either LLW or TRU waste.

A conservative engineering analysis (Ref. 60) calculated that a deflagration of 150 $ft^3$ of acetylene in a hermetically sealed enclosure with a volume of 18,085 $ft^3$ will yield an overpressure of approximately 22 psig, which is equivalent to the external static compression pressure determined to be necessary to cause failure of metal waste drums. However, because the acetylene is dissolved in an acetone carrier, the release process will be relatively slow. The deflagration of the entire container content is unlikely to occur without sufficient dispersion (due to the duration of the release) to prevent flammability of a large fraction of the total. Therefore, a conical jet from a 1-inch orifice is modeled consistent with Site methodology.

The length of the conical jet is estimated to be 16.7 feet based on the fact that "100-fold dilution will be achieved by jet action alone within a distance of 200 nozzle diameters." The quantity of acetylene released is approximately 10% of the total content, or 15 $ft^3$ from a 150 $ft^3$ cylinder. The release is determined to be contained within a conical jet with a volume of 141 $ft^3$. The mixture concentration is therefore 10.6%, which is well within the flammable range. The resultant overpressure from the deflagration explosion would be approximately 0.31 psig for a room volume of 105,000 $ft^3$, 0.78 psig for a room volume of 49,500 $ft^3$, and 3.3 psig for a room volume of 12,540 $ft^3$. The overpressure will occur virtually uniformly throughout the room as the explosion evolves. This overpressure is much less than 22 psig and is not sufficient to produce lid failure of 55-gallon drums. The analysis in the Building 371/374 Complex BIO concludes that a 15 $ft^3$ release of acetylene into a room with a volume greater than approximately 12,000 $ft^3$ would result in an overpressure that does not exceed 3.5 psig (which is the peak overpressure judged to be a reasonable internal criterion to ensure that damage within the Building 371/344 Complex would be localized). However, it is conservatively assumed that some of the exposed metal waste containers are breached because of impacts with debris resulting from the explosion overpressure effects.

This explosion scenario is modeled as a 10 minute release. A ground-level (non-lofted) release of the radioactive material is assumed. Two cases are evaluated, one each for medium and substantial construction facilities. There is no source of heavy falling debris in the light construction facilities or open storage areas.

*Scenario Modeling Assumptions:* spill; confined material; 10 minute duration, non-lofted plume.

Accident Frequency

The postulated accident scenario is judged to be *extremely unlikely* because it requires: (1) the failure of the acetylene cylinder or associated plumbing; (2) acetylene mixing with room air to form a flammable air/gas mixture; and (3) introduction of an ignition source. The flammable mixture will only exist for a limited time due to continued mixing, which could be enhanced by active ventilation (an expected condition even though not credited, since one condition for welding is that general ventilation be established per HSP 12.11, *Welding, Cutting, and Brazing*). The likelihood of this scenario is primarily defined by the following conditions or assumptions made in the analysis:

- The breach of flammable gas containers used in the performance of activities must be an *unlikely* event due to container resistance to impacts (an attribute of the ; and
- A hot work control program (an attribute of the ***fuel/combustible loading and ignition source control*** administrative control) shall be implemented for the waste management facilities to make flammable gas explosions in areas containing staged, stored, or in-process radioactive material *unlikely* events.

Inherent in the likelihood determination is the resistance of the metal waste drum (an attribute of the ***container integrity*** administrative control) to overpressure events requiring at least 22 psig overpressure to result in container failure.

*Scenario Modeling Assumptions: extremely unlikely* event.

Material-At-Risk

An unconfined deflagration of 150 $ft^3$ of acetylene in a waste storage room (with a volume greater than 12,000 $ft^3$) results in a peak overpressure less than the 22 psig required to breach a metal waste container crediting the ***container integrity*** control. This overpressure is not sufficient to rupture metal containers and it is also insufficient to topple stacked containers because the overpressure is essentially uniform throughout the room (*i.e.*, the pressure will be exerted on the containers from all sides).

The waste containers stored in waste management facilities are impacted by the overpressure event due to falling debris (*e.g.*, overhead equipment, HVAC ducts, etc.) that can fall onto exposed containers and lead to a breach of some containers. This scenario is postulated to occur only in medium or substantial construction facilities. There is no source of heavy falling debris in the light construction facilities or open storage areas. There are no medium or substantial construction waste management facilities that exclusively store LLW; therefore this event would involve a combination of LLW containers, TRU waste containers, and POCs. Because of the MAR difference and similar container strength of LLW and TRU waste drums, the TRU waste drums bound any release from LLW drums. In addition, the radiological material inventory is assumed to be composed of only TRU waste drums rather than a mixture of POCs and TRU waste containers. This is conservative because POCs are more resistant to breaches than TRU waste containers, and analysis of the POCs indicates that they are not susceptible to breach from falling material unless they are impacted on the side. Since no waste containers are expected to topple, the impact on exposed containers will be on the top of the container. Even though the amount of MAR that can be packaged in a metal box/SWB is more than for a 55-gallon drum (320 grams versus 200 grams), the 55-gallon drum is assumed to be the container type impacted in this scenario because of (1) the large scale of the event, (2) the number of TRU waste drums that can be stored in the same footprint as a metal box/SWB (at least 6 drums), and (3) the fact that the majority of TRU waste is packaged in 55-gallon drums.

Very few ceiling fixtures in waste storage areas have sufficient mass to penetrate drums when dropped from the ceiling. The approach taken in the evaluation of a seismic event (see Section 8.4.2, *NPH/EE Scenario 1 – DBE Event-Induced Spill*) will be used to assess the conservatism of the container breach assumptions. The Beyond Design Basis Earthquake (BDBE) event analyzed in Section 8.4.3, *NPH/EE Scenario 2 – BDBE Event-Induced Spill*, assumes more ceiling damage than that expected to result from an acetylene explosion. A similar methodology to that used for evaluation of the earthquake caused spill scenarios will be used here to estimate damage ratios for this facility explosion scenario.

Due to the similar damage associated with a facility explosion and a DBE event (i.e., falling overhead objects/no facility structure collapse), the damage ratio for substantial construction facilities is the same as derived in Section 8.4.2. It is assumed that 10% of the exposed drums in the facility will be impacted by falling objects. This value represents one-fifth of the damage associated with a BDBE event in which structural failure of the facility occurs and 50% of the exposed drums are impacted by falling objects (*e.g.*, overhead equipment, structural supports, etc.) as discussed in Section 8.4.3. The same ratioing can be utilized to determine a damage ratio for an explosion in a medium construction facility. Medium construction facilities have less suspended overhead objects than substantial construction facilities because the main support beams (to which these objects are attached) generally cover about 7% of the facility floor space (Ref. 61). Applying the same ratio used above, only 1.5% of the exposed drums in medium construction facilities will be subject to the falling debris during a facility explosion.

Of the drums subjected to falling debris, it is assumed that 10% of the drums are breached to the point of losing confinement of radioactive material contents (*i.e.*, penetration of drum and internal packaging). The 10% value is also based on engineering judgment and takes into account the strength of the drums (*i.e.*, ***waste container integrity*** control) and the types of overhead



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materials that may fall (*i.e.*, limited amount of heavy, penetrating overhead objects). Based on these assumptions, the damage ratio is 0.15% (1.5% × 10%) of the exposed drum inventory for medium construction facilities and 1% (10% × 10%) of the exposed drum inventory (i.e., drum lids exposed to the ceiling) for substantial construction facilities.

Two cases are evaluated: Case A involves a total of 12,000 TRU waste drums in a medium construction facility, and Case B involves a total of 12,000 TRU waste drums in a substantial construction facility. For the purposes of this evaluation, it is assumed that all of the waste drums are stacked four high so that the number of drums stacked on the top tier is one fourth of the total number of containers. The number of exposed drums will differ for each facility due to unique stacking arrangements.

Case A: 3,000 exposed TRU drums on upper tier (medium construction facility)

Case B: 3,000 exposed TRU drums on upper tier (substantial construction facility)

The above drum count assumptions are not restrictions on facility or room inventories or stacking arrangements, but are used here to model a representative facility explosion scenario.

The majority of TRU waste drums at the Site contain less than the 200 grams WG Pu ***container fissile material loading*** limit. Because this scenario is postulated to impact a large number of drums, it is appropriate to use the 95$^{th}$ percentile upper confidence limit (UCL) gram loading value for waste containers at the Site plus some conservatism to account for uncertainty and fluctuations in the Site container gram loading. The 95$^{th}$ percentile UCL for the Site as of June 1998 is 95 grams WG Pu per TRU waste drum (Ref. 49). Adding 20% conservatism, the 95$^{th}$ percentile UCL becomes 114 grams WG Pu per drum, which was used in the evaluation of this scenario. The 95$^{th}$ percentile UCL value will be reviewed on an annual basis and updated as necessary. For purposes of the SES/USQD process, a higher value than the 95$^{th}$ percentile UCL of 95 grams WG Pu but less than the more conservative analyzed value of 114 grams WG Pu will not constitute a reduction in the margin of safety. By using this approach, there is no need for establishing facility MAR limits.

The effective MAR for this facility explosion scenario is determined by the following equation:

**Effective MAR = # of exposed drums × facility damage ratio × container MAR**

The effective MAR for the two facility construction can be determined as shown below. The effective MAR values for both cases are presented in Table 13-2.

Medium construction facilities:

Effective MAR = # of exposed drums × 0.0015 × 114 g WG Pu

Substantial construction facilities:

Effective MAR = # of exposed drums × 0.01 × 114 g WG Pu



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**Table 13-2** Effective MAR Values for Explosion Scenario 2

| Case | Number of Top Tier Drums Impacted by Falling Debris | Total MAR (grams WG Pu) [Based on 114 g per container] | Effective MAR (grams WG Pu) | |
|---|---|---|---|---|
| | | | Medium Construction facility (DR = 0.15%) | Substantial Construction facility (DR = 1%) |
| A | 3,000 | 342,000 | 513 | N/A |
| B | 3,000 | 342,000 | N/A | 3,420 |

A blended DCF of 3.04E+7 is used to conservatively account for the population of waste containers with IDCs that should be modeled with Solubility Class W (Ref. 50).

*Scenario Modeling Assumptions:*

Case A: 3,000 exposed drums; aged WG Pu; 342,000 grams (using a 95$^{th}$ % UCL container loading value); Blended DCF; DR = 0.0015 (medium construction facility).

Case B: 3,000 exposed drums; aged WG Pu; 342,000 grams (using a 95$^{th}$ % UCL container loading value); Blended DCF; DR = 0.01 (substantial construction facility).

Accident Consequence

Case A: The radiological dose consequences of the explosion-induced spill involving 3,000 exposed drums in a medium construction facility are *moderate* (0.12 rem) for the MOI @ 1,200 m, *low* (4.1E-2 rem) for the MOI @ 2,367 m, and *moderate* (5.6 rem) for the CW. The resulting risk class for the scenario is Risk Class III for the MOI @ 1,200 m IW (*extremely unlikely* frequency, *moderate* consequences), Risk Class IV for the MOI @ 2,367 m (*extremely unlikely* frequency, *low* consequences), and Risk Class III for the CW (*extremely unlikely* frequency, *moderate* consequences).

Case B: The radiological dose consequences of the explosion-induced spill involving 3,000 exposed drums in a substantial construction facility are *moderate* (0.77 rem) for the MOI @ 1,200 m, *moderate* (0.27 rem) for the MOI @ 2,367 m, and *high* (37 rem) for the CW. The resulting risk class for the scenario is Risk Class III for the MOI @ 1,200 m and 2,367 m (*extremely unlikely* frequency, *moderate* consequences) and Risk Class II for the CW (*extremely unlikely* frequency, *high* consequences).

For the IW located in the vicinity at the time of the event, a facility explosion could result in death or serious injury due to blast effects and the heat and flame associated with the deflagration. There is the potential for the IW to inhale radioactive material being lofted by the spilled containers following the explosion but the IW would have to remain in the vicinity of the accident. The radiological dose consequences to the IW that is in the vicinity of the explosion are qualitatively judged to be *high* for both cases due to (1) the very high likelihood that the IW is incapacitated by the explosion and unable to exit the area (*i.e.*, the IW receives higher radiological consequences since they are unable to evacuate), and (2) the moderate amount of radiological material that is released. The resulting risk class for Case A and Case B is Risk Class II to the IW (extremely *unlikely* frequency, *high* consequences).



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## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.002 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

*Describe Scenario:*

Explosion Scenario 2: Case A
3,000 TRU Waste Drums
MOI Distance = 1,200 m
Medium Construction Facility

Version 1.2

| Default Parameters | | Change Options: Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| *Effective MAR, Including DR (g)* = | 5.13E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 5.13E-02

RESULTS

| Number of HEPA Stages | Plume Doses: CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 5.6E+00 | 1.2E-01 |
| One | 5.6E-03 | 1.2E-04 |
| Two | 1.1E-05 | 2.3E-07 |
| Three | 2.2E-08 | 4.6E-10 |
| Four | 4.5E-11 | 9.2E-13 |

**Explosion Scenario 2 – Case A; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.002 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Explosion Scenario 2: Case A
3,000 TRU Waste Drums
MOI Distance = 2,367 m
*Medium Construction Facility*

Version 1.2

| Default Parameters | | Change Options: Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 5.13E+02 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/$m^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/$m^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 5.13E-02

RESULTS

| Number of HEPA Stages | Plume Doses: CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 5.6E+00 | 4.1E-02 |
| One | 5.6E-03 | 4.1E-05 |
| Two | 1.1E-05 | 8.2E-08 |
| Three | 2.2E-08 | 1.6E-10 |
| Four | 4.5E-11 | 3.3E-13 |

**Explosion Scenario 2 – Case A; Radiological Dose Consequences; 2,367 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.010 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 1,200 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Explosion Scenario 2: Case B
3,000 TRU Waste Drums
MOI Distance = 1,200 m
Substantial Construction Facility

Version 1.2

| Default Parameters | | Change Options: Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 3.42E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/m$^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/m$^3$) = | 2.05E-04 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.42E-01

RESULTS

| Number of HEPA Stages | Plume Doses: CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 3.7E+01 | 7.7E-01 |
| One | 3.7E-02 | 7.7E-04 |
| Two | 7.4E-05 | 1.5E-06 |
| Three | 1.5E-07 | 3.1E-09 |
| Four | 3.0E-10 | 6.1E-12 |

**Explosion Scenario 2 – Case B; Radiological Dose Consequences; 1,200 m**

## Non-Criticality Accidents

| Input Selections | Option/Value | Description |
|---|---|---|
| Scenario (1-7) = | 6 | Spill |
| Material (1-8) = | 2 | Aged WG Pu |
| $\chi$/Q Meteorology (1-2) = | 2 | 95th % |
| Breathing Rate (1-3) = | 3 | Heavy Activity |
| Form of Material (1-11) = | 1 | Confined Mat |
| Solubility Class (1-3) = | 2 | W |
| Damage Ratio = | 0.010 | |
| Material at Risk (g) = | 3.42E+05 | |
| Ambient Leakpath Factor (not HEPA) = | 1.00E+00 | |
| TNT Explosion Equivalent (g) = | 0 | |
| Mass of Matrix, if Applicable (g) = | 0 | |
| Plume/Release Duration (min) = | 10 | |
| Least Distance to Site Boundary (m) = | 2,367 | |
| Evaluate Non-Criticality Accident? (Y/N) | Y | |

| User-Specified Isotopic Mix | |
|---|---|
| Isotope | Mass Fraction |
| | |
| SUM | 0.000 |

Describe Scenario:

Explosion Scenario 2: Case B
3,000 TRU Waste Drums
MOI Distance = 2,367 m
Substantial Construction Facility

Version 1.2

| Default Parameters | | Change Options: Accept Default? | New Value | Value Used |
|---|---|---|---|---|
| Airborne Release Fraction = | 1.0E-03 | Y | | 1.0E-03 |
| Respirable Fraction = | 1.0E-01 | Y | | 1.0E-01 |
| Breathing Rate ($m^3$/s) = | 3.6E-04 | Y | | 3.6E-04 |
| Dose Conversion Factor (rem/g-mix) = | 4.35E+07 | N | 3.04E+07 | 3.04E+07 |
| Effective MAR, Including DR (g) = | 3.42E+03 | | | |
| Plume Expansion Factor = | 1.000 | | | |
| Collocated Worker $\chi$/Q (s/m$^3$) = | 9.94E-03 | | | |
| Public $\chi$/Q (s/m$^3$) = | 7.30E-05 | | | |
| Ambient Leakpath Factor (Not HEPA) = | 1.00E+00 | | | |

Respirable Initial Source Term (g) = 3.42E-01

RESULTS

| Number of HEPA Stages | Plume Doses: CW (rem) | MOI (rem) |
|---|---|---|
| Zero | 3.7E+01 | 2.7E-01 |
| One | 3.7E-02 | 2.7E-04 |
| Two | 7.4E-05 | 5.5E-07 |
| Three | 1.5E-07 | 1.1E-09 |
| Four | 3.0E-10 | 2.2E-12 |

**Explosion Scenario 2 – Case B; Radiological Dose Consequences; 2,367 m**

## Table 13-3 Explosion Scenario 2: Case A - Explosion in Waste Storage Area (Medium Construction Facility)

| | |
|---|---|
| Hazard | 4B (Radioactive Materials/Waste Container), and 5B (Thermal Energy/Flammable Gases) |
| Accident Type | Explosion involving 3,000 exposed TRU waste drums; flammable gas explosion in room creating falling debris that breaches waste drums<br>Effective MAR = 513 grams of aged WG Pu (0.15% damage ratio, 114 grams container MAR); accident occurs in a medium construction waste management facility |
| Cause or Energy Source | [energy sources] 5C (Hot Work), 5E (Electric Power System), and 5H (Transport Vehicles) |
| Applicable Activity(ies) | [most likely] RA/SH; [less likely] CC, CR, RT, GN |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Extremely Unlikely | Not Applicable | @ 1,200 m<br>Moderate<br>0.12 rem<br>@ 2,367 m<br>Low<br>4.1E-2 rem | Not Applicable | @ 1,200 m<br>III<br>@ 2,367 m<br>IV | Flammable Gas Container<br>Hot Work Control<br>Container Integrity<br>Flammable Gas Use<br>Container Fissile Material Loading<br>Training | C<br>C<br>C<br>C<br>C<br>D | P<br>P<br>M<br>M<br>M<br>P | AOL 9<br>AOL 8<br>AOL 1<br>AOL 9<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Extremely Unlikely | Not Applicable | Moderate<br>5.6 rem | Not Applicable | III | Same as MOI | | | |
| IW | Anticipated | Extremely Unlikely | Not Applicable | High | Not Applicable | II | Flammable Gas Container<br>Hot Work Control<br>Container Integrity<br>Flammable Gas Use<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | P<br>P<br>M<br>M<br>M<br>P/M<br>M<br>M | AOL 9<br>AOL 8<br>AOL 1<br>AOL 9<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"

## Table 13-4 Explosion Scenario 2: Case B - Explosion in Waste Storage Area (Substantial Construction Facility)

| | |
|---|---|
| **Hazard** | 4B (Radioactive Materials/Waste Container), and 5B (Thermal Energy/Flammable Gases) |
| **Accident Type** | Explosion involving 3,000 exposed TRU waste drums; flammable gas explosion in room creating falling debris that breaches waste drums<br>Effective MAR = 3,420 grams of aged WG Pu (1% damage ratio, 114 grams container MAR); accident occurs in a substantial construction waste management facility |
| **Cause or Energy Source** | [energy sources] 5C (Hot Work), 5E (Electric Power System), and 5H (Transport Vehicles) |
| **Applicable Activity(ies)** | [most likely] RA/SH; [less likely] CC, CR, RT, GN |

| Receptor | Scenario Frequency | | Scenario Consequence | | Scenario Risk Class | | Protective Feature | Feature Type Credited Defense | Feature Purpose Prevent Mitigate | Reference to TSRs |
|---|---|---|---|---|---|---|---|---|---|---|
| | Without Prevention | With Prevention | Without Mitigation | With Mitigation | Without Prevention/ Mitigation | With Prevention/ Mitigation | | | | |
| MOI | Anticipated | Extremely Unlikely | Not Applicable | $\boxed{@ 1,200 m}$<br>Moderate<br>0.77 rem<br>$\boxed{@ 2,367 m}$<br>Moderate<br>0.27 rem | Not Applicable | $\boxed{@ 1,200 m}$<br>III<br>$\boxed{@ 2,367 m}$<br>III | Flammable Gas Container<br>Hot Work Control<br>Container Integrity<br>Flammable Gas Use<br>Container Fissile Material Loading<br>Training | C<br>C<br>C<br>C<br>C<br>D | P<br>P<br>M<br>M<br>M<br>P | AOL 9<br>AOL 8<br>AOL 1<br>AOL 9<br>AOL 4<br>AC 5.6 |
| CW | Anticipated | Extremely Unlikely | Not Applicable | High<br>37 rem | Not Applicable | II | Same as MOI | | | |
| IW | Anticipated | Extremely Unlikely | Not Applicable | High | Not Applicable | II | Flammable Gas Container<br>Hot Work Control<br>Container Integrity<br>Flammable Gas Use<br>Container Fissile Material Loading<br>Training<br>Emergency Response<br>LS/DW | C<br>C<br>C<br>C<br>C<br>D<br>D<br>D | P<br>P<br>M<br>M<br>M<br>P/M<br>M<br>M | AOL 9<br>AOL 8<br>AOL 1<br>AOL 9<br>AOL 4<br>AC 5.6<br>AC 5.5<br>AC 5.5 |

Notes: Underlined Credited Protective Features are included as inherent and credited controls in the Without Prevention/Mitigation Scenario Frequency/Consequence/Risk Class determinations.

The "*without mitigation*" scenario is evaluated when a facility system can be credited as a mitigative protective feature (*e.g.*, automatic sprinkler system, HEPA filtration, etc.). When a facility system cannot be credited, the ***Without Mitigation*** and ***Without Prevention/Mitigation*** columns are marked "*Not Applicable.*"



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### 13.2.3 Control Set Vulnerability

Two preventive features have been credited in the determination of the explosion scenario frequency and four mitigative features have been credited in the scenario consequence determination.

The credited preventive features for Cases A and B are:

1. the administrative control that assures flammable gas containers (an attribute of the ***flammable gas use*** administrative control) are *unlikely* to be breached during use (all receptors); and
2. the hot work control program (an attribute of the ***fuel/combustible loading and ignition source control*** administrative control) that requires a program be implemented for waste management facilities to make flammable gas explosions in areas containing staged, stored, or in-process radioactive material *unlikely* events (all receptors).

The credited mitigative features Cases A and B are:

1. the ***container fissile material loading*** administrative control of (all receptors);
2. the administrative control that prohibits the use of acetylene in rooms of less than 12,000 $ft^3$ (an attribute of the ***flammable gas use*** administrative control) (all receptors);
3. the ***container integrity*** administrative control (*i.e.*, cannot be breached by an explosion peak overpressure less than 22 psig) (all receptors);
4. the ***emergency response*** administrative control of an (IW only).

Failure of the flammable gas containers preventive feature (inadequate design, failure to meet DOT specifications) could result in some cylinder breach events becoming *anticipated* events.

Failure of hot work control program requirements (control of ignition sources, fire watches, *etc.*) could result in some events becoming *anticipated* events.

Failure of the ***container fissile material loading*** mitigative feature (higher MAR containers) would result in additional MAR and a corresponding increase in radiological dose.

Failure of the ***flammable gas use*** control that prohibits the use of acetylene in rooms of less than 12,000 $ft^3$ could result in increased overpressure effects resulting in increased MAR and a corresponding increase in radiological dose.

Failure of the ***container integrity*** mitigative feature (potential breach of containers from explosion rather than just from debris) could result in additional MAR and a corresponding increase in radiological dose.

Failures of the ***emergency response*** mitigative feature (inadequate emergency plan; one frequency bin reduction due to sensibility of evacuation and standardized guidance) could result in additional IW exposure to airborne radioactive materials.

In all situations discussed above, the following defense-in-depth features tend to mitigate or prevent the scenario but are not credited in the analysis:

- ***Training*** (all receptors): IW ***training*** is an additional mitigative feature that can reduce IW consequences as a reinforcement of the ***emergency response*** evacuation guidance. Operator ***training*** is an additional preventive feature that can potentially reduce the likelihood of damage to flammable gas cylinders and associated equipment or the buildup of flammable gases.
- ***LS/DW*** (IW only): Facility management or other personnel can utilize the ***LS/DW system*** to reduce IW consequences by announcing the facility explosion to facility personnel.

### 13.2.4 Explosion Scenario Assumptions

In the evaluation of the facility explosion scenario, assumptions are identified for prevention and/or mitigation of the accident. Table 13-5 presents a listing of the assumptions specified in the accident evaluation. The scenario(s)/case(s) to which each assumption applies are listed in the table along with the impact of the assumption. The ***bold italicized*** text in the Assumption Impact column identifies a credited protective feature that is carried forward to the *Waste Management Facilities Technical Safety Requirements.*

**Table 13-5** Explosion Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| TRU waste containers contain no more than 200 grams WG Pu equivalent in drums and 320 grams WG Pu equivalent in metal boxes/SWBs. | Explosion Scenario 2 | Sets the MAR for determining the bounding container type postulated for a facility explosion. ***Container Fissile Material Loading*** |
| The 95th percentile UCL gram loading value for TRU drums is appropriate for facility explosions. | Explosion Scenario 2 | Sets the total MAR for the facility explosion scenario. |
| Metal waste drums cannot be breached by an external explosion peak overpressure less than 22 psig. | Explosion Scenario 2 | Limits the MAR associated with facility explosions to containers breached by falling debris versus direct explosion impacts. ***Container Integrity*** |
| A hot work control program shall be implemented to make flammable gas explosions in areas containing staged, stored, or in-process radioactive material *unlikely* events. | Explosion Scenario 2 | Reduces the likelihood of facility explosions potentially impacting radioactive material by one frequency bin. ***Fuel/Combustible Loading and Ignition Source Control - Hot Work Control*** |

**Table 13-5** Explosion Scenario Assumptions

| ASSUMPTION | SCENARIO | ASSUMPTION IMPACT |
|---|---|---|
| The use of flammable gas in rooms of less than 12,000 $ft^3$ is prohibited. | Explosion Scenario 2 | Limits the MAR associated with facility explosions to containers breached by falling debris versus direct explosion impacts.<br>***Flammable Gas Use – Prohibiting the Use of Flammable Gas in rooms of less than 12,000 $ft^3$*** |
| The flammable gas inventory in rooms greater than 12,000 $ft^3$ shall be limited to 150 $ft^3$. | Explosion Scenario 2 | Limits the MAR associated with facility explosions to containers breached by falling debris versus direct explosion impacts.<br>***Flammable Gas Use - Flammable Gas Inventory*** |
| Waste Management Facilities will develop facility-specific Emergency Plans. | Explosion Scenarios 2 | Reduces the exposure to the IW to releases.<br>***Emergency Response*** |



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# 14. DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

## 14.1 INTRODUCTION

The *Waste Management Facilities Technical Safety Requirements (TSRs)* (Ref. 1), provided as a stand-alone document, with applicability to specific RMRS waste management facilities. Requirements are established to define the conditions, safe boundaries, and Administrative Controls (ACs) necessary to assure safe operations and reduce the risk to the MOI, CW, IW, and the environment from an uncontrolled release of hazardous materials. The *Waste Management Facilities TSRs*, hereafter referred to as simply TSRs, are a consolidated set of controls, with each individual control applicable to one or more waste management facilities depending on the facility mission and the activities performed within the facility. There are four types of controls used to provide this assurance: Limiting Conditions for Operations (LCOs), Surveillance Requirements (SRs), ACs, and Design Features. An applicability statement and/or matrix is provided for each individual control that identifies the controls that each waste management facility must implement and maintain.

This chapter derives the TSRs and identifies the operational controls defining the safe conditions based on the safety analysis presented earlier in this NSTR. Compliance with the TSRs ensures that the health and safety of the MOI and CW are protected from an uncontrolled release of radioactive and hazardous materials, and ensures that potential risks to the IW are reduced based on the implemented controls.

In addition, this chapter establishes the bases for the selection of LCOs, SRs, ACs, and Design Features. The TSRs were selected and prepared in accordance with DOE 5480.22, *Technical Safety Requirements* (Ref. 6) and the *Document of Example Technical Safety Requirements, Volume I* (Ref. 62).

## 14.2 TYPES AND DERIVATION OF REQUIREMENTS

### 14.2.1 Limiting Conditions for Operations

LCOs are imposed on safety-related structures, systems, and components (SSCs) credited in this NSTR to reduce the frequency of postulated accidents or mitigate the consequences of postulated accidents to the MOI and/or CW. LCOs provide the lowest functional capability or performance levels of safety-related SSCs and their support systems, and are required for normal, safe operation of waste management facilities. Table 14-1 correlates specific, credited safety features identified in the safety analysis to the appropriate TSR LCO. Waste management facility LCOs address the following systems:

- Automatic Sprinkler System (facility)
- Glovebox Fire Suppression
- Filtered Exhaust Ventilation System (facility or waste repackaging confinement area)
- Glovebox Filtered Exhaust Ventilation
- Criticality Alarm System (future)



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### 14.2.2 Surveillance Requirements

SRs are requirements relating to testing, calibration, or inspection to assure operability of safety-related SSCs and their support systems. This section of the TSRs contains the requirements necessary to maintain operation of waste management facilities within applicable LCOs. In the event that SRs are not successfully completed or accomplished within their specified frequency, the systems or components involved are assumed to be not operable and required actions defined by the LCOs are taken until the system or components can be shown to be operable.

SRs for each system or component identified in a specific LCO are provided subsequent to the LCO. The SRs add assurance that those systems and components that the safety analysis credits for prevention of postulated accidents or mitigation of postulated accident consequences will perform their intended functions.

### 14.2.3 Administrative Controls

ACs are credited in the safety analysis to help assure the safe operation of waste management facilities. The six ACs listed below are from the *Administrative Control Template* developed by Kaiser-Hill for use in developing Site, Hazard Category 2 Nuclear Facility TSRs (Ref. 63).

- Organization and Management
- Inventory Control and Material Management
- Control of Combustible Materials and Ignition Sources
- Maintenance and Surveillance of SC-3 SSCs
- Emergency Response
- Safety Management Programs (SMPs)

Each of the above ACs consist of credited programmatic elements. Additionally, some of the ACs provide discrete controls/limits that have been credited in the safety analysis. These specific controls or restrictions, referred to as Administrative Operating Limits (AOLs), are credited as providing a reduction in postulated accident scenario initiation frequency and/or a reduction in postulated accident scenario consequences. Such controls are more precise and discrete than those defined by a SMP or the program elements of a SMP. The ACs with specific controls or restrictions have verification requirements and requirements for actions following discovery of a noncompliance with the control or restriction. Examples of ACs with specific controls or restrictions include: Inventory Control and Material Management (AC 5.2) and Control of Combustible Materials and Ignition Sources (AC 5.3). Table 14-2 correlates specific administrative controls credited in the safety analysis to the appropriate TSR AC.

### 14.2.4 Design Features

Design Features are passive features that reduce the frequency and/or mitigate the consequences of uncontrolled releases of radioactive or other hazardous materials from waste management facilities for the postulated accident scenarios analyzed in this NSTR. Design



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Feature descriptions are provided in the TSRs to assure that evaluations of proposed changes or modifications to the Design Features are properly performed and documented, consistent with requirements specified in the TSRs. An example of a Design Feature credited in this NSTR is confinement enclosure (gloveboxes, Perma-Cons, C-cells, etc.) structural integrity that prevents fires in confinement enclosures from impacting waste containers in the adjacent waste storage areas. Maintenance of Design Features is addressed in the TSRs in Section 6, Design Features. Table 14-1 correlates the Design Features specifically credited in the hazard and accident analysis to the TSR Design Feature.

## 14.3 TECHNICAL SAFETY REQUIREMENTS COVERAGE

This section lists the features identified in this NSTR that are needed to provide MOI, CW, and IW safety, or significant defense-in-depth. The definitions used throughout this NSTR in determining the control feature are as follows:

***MOI Safety:*** Those features that have been determined to be essential to assuring public safety related to immediate fatalities or serious injuries, or that maintain the consequences of facility operations below an established evaluation guideline. These features are identified as System Category (SC)-1/2 SSCs if the MOI could sustain *moderate* or *high* consequences, depending on scenario frequency.

***CW Safety:*** Those features that have been determined to be essential to assuring worker nuclear safety related to immediate fatalities or serious injuries, or that maintain the consequences of facility operations below an established evaluation guideline. These features are identified as System Category (SC)-1/2 SSCs if the CW could sustain *moderate* or *high* consequences, depending on scenario frequency.

***IW Safety:*** Those features that provide protection to the IW from the hazards of facility operation, exclusive of standard industrial hazards. Worker safety features include both facility SSCs and administrative features. SSCs that are major contributors to worker safety are designated as SC-3 SSCs.

***Defense-in-Depth:*** Those features that provide an additional layer of defense against release of hazardous materials to the environment. Defense-in-depth features include both facility SSCs and administrative features. SSCs that are major contributors to defense-in-depth are designated as SC-3 SSCs.

Table 14-1 lists all of the controls concerning waste management facility SSCs identified during the hazard evaluation and accident analysis presented in this NSTR. This table describes the credited control and the safety feature being relied upon for that control. The control feature designated as public or collocated worker safety (MOI/CW), immediate worker safety (IW), or defense-in-depth (DID), as defined above, or any combination of these features. The control type is designated and identifies the system category of the credited control (i.e., SC-1/2 or SC-3). The TSR control column provides the linkage to the TSRs to indicate control coverage. And finally, the accident scenario column provides the linkage to the accident scenario where the control is credited.

## Table 14-1 Waste Management Facility Controls, Safety Features, and TSR Control

| Control | Safety Feature | Control Feature[1] | | | Control Type | TSR Control | Accident Scenario |
|---|---|---|---|---|---|---|---|
| | | MOI/ CW | IW | DID | | | |
| *Automatic Sprinkler System* | The safety function of automatic sprinkler systems is to mitigate the effects of the fire and to prevent SH and RT fires from propagating into a larger fire. Automatic Sprinkler Systems (with few exceptions) are located in all TRU waste storage areas. | ✓ | ✓ | ✓ | SC-1/2 | LCO 3.1 | Fire Scenario 2 – Case B<br>Fire Scenario 3 – Case B |
| *Glovebox Fire Suppression System* | The safety function of automatic glovebox fire suppression systems is to provide mitigation of RT fires inside the glovebox as well as preventing a fire from propagating outside the glovebox and potentially affecting nearby waste containers. | ✓ | ✓ | ✓ | SC-1/2 | LCO 3.2 | Fire Scenario 3 – Case B |
| *Maintenance and Surveillance of SC-3 SSCs (Fire Extinguishers)* | Fire extinguishers can be used by facility personnel to prevent a small fire from propagating into a larger fire in waste storage areas. | | | ✓ | SC-1/2 | AC 5.4 | Fire Scenario 1<br>Fire Scenario 2<br>Fire Scenario 3 |
| *Maintenance and Surveillance of SC-3 SSCs (Flow Alarm/Fire Department Response)* | The safety function of flow alarms is to provide an alarm to the Central Alarm Station (CAS) and Fire Dispatch Center (FDC) to indicate a fire in sprinklered areas of waste management facilities. Receipt of the alarm will provide notification to the Fire Department, initiating Fire Department response to extinguish the fire and mitigate any fire related impacts. | ✓ | | ✓ | SC1/2 | LCO 3.1 | Fire Scenario 1<br>Fire Scenario 2<br>Fire Scenario 3 |
| *Maintenance and Surveillance of SC-3 SSCs (Fire Phones/Fire Department Response)* | Fire phones provide direct communication to the FDC assuring Fire Department response, which can minimize the duration of a fire in the waste storage area. | ✓ | ✓ | ✓ | SC-3 | AC 5.4 | Fire Scenario 1<br>Fire Scenario 2<br>Fire Scenario 3 |
| *Maintenance and Surveillance of SC-3 SSCs (Fire Phones/Fire Department Response)* | Fire phones provide an alarm (fire bells inside the facility) to notify personnel inside waste management facilities to evacuate resulting in reduced IW consequences. | | ✓ | ✓ | SC-3 | AC 5.4 | Fire Scenario 1<br>Fire Scenario 2 |
| *Maintenance and Surveillance of SC-3 SSCs (LS/DW)* | Facility management or other personnel can utilize the LS/DW system to reduce IW consequences by providing indication of fires, spills, and explosions to facility personnel. | | ✓ | ✓ | SC-3 | AC 5.4 | All Scenarios |
| *Filtered Exhaust Ventilation System* | The safety function of HEPA filtration systems is to provide HEPA filtration of exhaust ventilation from waste storage areas to reduce the consequences to the MOI and CW. | ✓ | | ✓ | SC-1/2 | LCO 3.3 | Fire Scenario 3 – Case B<br>Spill Scenario 4, Case B |



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**Table 14-1** Waste Management Facility Controls, Safety Features, and TSR Control

| Control | Safety Feature | Control Feature[1] | | | Control Type | TSR Control | Accident Scenario |
|---|---|---|---|---|---|---|---|
| | | MOI/ CW | IW | DID | | | |
| *Glovebox Filtered Exhaust Ventilation* | The safety function of glovebox HEPA filtration systems is to provide HEPA filtration during normal repackaging and treatment operations as well as during small fires inside the glovebox that are mitigated by the glovebox fire suppression system. | ✓ | | | SC-1/2 | LCO 3.4 | Fire Scenario 3, Case B |
| *Design Features (Building Structure).* | The safety function of exterior walls is to reduce the impact on radioactive waste containers from structural impacts caused by NPH and facility explosions. These include high winds, tornadoes, wind driven missiles, atmospheric pressure changes, heavy rain, heavy snow, aircraft crash, and seismic events. | ✓ | ✓ | ✓ | SC-3 | Design Feature | NPH Scenario 1<br>NPH Scenario 2 |
| *Maintenance and Surveillance of SC-3 SSCs (Confinement Enclosure Integrity)* | The safety function of confinement enclosure (Perma-Cons, C-cells, and gloveboxes) integrity is to prevent RT fires from breaching confinement enclosures and impacting nearby waste containers. For RT spills in Perma-Cons and C-cells a reduced LPF can be credited. | ✓ | ✓ | | SC-3 | AC 5.4 | Fire Scenario 3 |

[1]MOI/CW (Public and collocated worker Safety), DID (Defense in depth feature), WS (immediate worker safety feature)



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## 14.4 ADMINISTRATIVE CONTROLS

### 14.4.1 Introduction

This section identifies the administrative controls that ensure administrative safety functions necessary for safe waste management facility operations. It builds upon the identification in the safety analysis of the preventive and mitigative administrative safety features necessary to protect the MOI, CW, IW, and the environment, or that provide significant elements of defense-in-depth. This section also identifies the administrative controls that ensure the administrative safety features identified in the hazard and accident analyses, including those applicable to all postulated accident scenarios (*i.e.*, assumed initial conditions). The administrative controls identified are contained in the TSRs.

### 14.4.2 Identification of Administrative Controls

The safety analysis assumption tables in this NSTR identify the administrative safety features considered significant for waste management facilities. These assumptions provide the broad set of administrative controls considered for accident prevention and/or mitigation, and from which the safety features specifically credited for reducing the risk of an accident to acceptable levels are derived. The administrative controls providing these safety features are captured by Table 14-2.

Table 14-2 correlates administrative safety features identified in the hazard and accident analyses to the administrative controls ensuring the conduct of those safety functions. The first column of the table presents the credited control as derived from the safety analysis. The second column identifies the safety feature(s) of the credited administrative control. The third column provides a cross-reference to the TSR ACs. The final column provides a cross-reference to the scenario in which each administrative control is credited. This column identifies the specific AOL in the TSR ACs.



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**Table 14-2** Credited Administrative Controls Matrix

| Credited Administrative Control | Safety Feature | TSR AC | Scenario |
|---|---|---|---|
| ***Container Integrity***<br><br>Waste containers, including POCs and Type B shipping containers, received at and stored in waste management facilities shall meet on-site transportation requirements. | • Reduces the likelihood of metal waste container fire-induced lid loss associated with expected fires to *Beyond Extremely Unlikely*.<br>• Reduces the likelihood of breaching metal waste containers by falls less than four feet to *Unlikely*.<br>• Reduces the likelihood of breaching metal waste containers by forklift tine impacts to *Unlikely* due to impact angle requirements needed to lead to failure.<br>• Reduces the likelihood of breaching metal waste containers by non-forklift tine impacts from material handling equipment to *Unlikely*.<br>• Reduces the likelihood of breaching a Type B shipping container or POC from forklift tine impacts to *Beyond Extremely Unlikely* due to impact angle requirements needed to lead to failure.<br>• Reduces the likelihood of breaching a Type B shipping container or POC from structural member or falling object impacts to *Beyond Extremely Unlikely* due to impact angle requirements and weight needed to lead to failure.<br>• Reduces the likelihood of breaching metal waste containers by an external explosion peak overpressure less than 22 psig to *Beyond Extremely Unlikely*.<br>• Reduces the likelihood of breaching a Type B shipping container or POC from any external fires expected during storage and handling operations to *Beyond Extremely Unlikely*.<br>• Sets the number of waste containers that will be breached in an aircraft crash. | AOL 1 | Fire Scenario 1<br>Fire Scenario 2<br>Spill Scenario 1<br>Spill Scenario 2<br>Spill Scenario 3<br>NPH Scenario 1<br>NPH Scenario 2<br>Explosion Scenario 2<br>Aircraft Crash Scenario 1 |
| ***Vented Containers*** | Reduces the likelihood of breaching metal waste containers by internal hydrogen explosions to *Extremely Unlikely* due to metal waste container venting. | AOL 3 | Explosion Scenario 1 |
| ***Container Fissile Material Loading***<br><br>The maximum inventory (WG Pu equivalent) per container is as follows:<br><br><u>LLW</u><br><br>55-Gallon Drum = 0.5 grams<br>Metal Box = 3 grams WG Pu equivalent<br><br><u>TRU Waste</u><br><br>55-Gallon Drum = 200 grams<br>Metal Box/SWB = 320 grams<br>POC = 1,255 grams | • Sets the potential MAR for SH spill and fire scenarios impacting LLW , TRU waste containers, including POCs. Note that the 95th Percentile UCL container inventory (plus 20% conservatism factor) is used to model seismic and facility explosion scenarios.<br>• Sets the potential MAR for the RT spill and fire scenarios impacting LLW containers.<br>• Sets the MAR for determining the bounding container type postulated for seismic and facility explosion scenarios. | AOL 4 | All Scenarios |

## Table 14-2 Credited Administrative Controls Matrix

| Credited Administrative Control | Safety Feature | TSR AC | Scenario |
|---|---|---|---|
| ***Container Stacking (Banding)***<br>Waste drums stacked above the second tier will be banded. | Preserves the assumption that a drop/fall of banded waste drums (stacked above the second tier) in operational spills or seismic-induced spills results in the equivalent release of material of one waste drum. | AOL 6 | Spill Scenario 1<br>Spill Scenario 2<br>Spill Scenario 3<br>NPH Scenario 2 |
| ***Inventory Control and Material Management Program – Liquids in Waste Prohibited***<br>Waste containers to be stored in waste management facilities shall not contain liquids. | Reduces the likelihood of internal hydrogen explosions in containers to *Extremely Unlikely* by reducing the potential rate of hydrogen generation and/or metal waste container vent plugging. | AOL 7 | Explosion Scenario 1 |
| ***Fuel/Combustible Loading and Ignition Source Control***<br>A combustible material and ignition source control program shall be implemented.<br><u>Attributes of combustible material control include</u>:<br>• high heat release rate combustible material restrictions;<br>• <u>no wooden crates</u> in internal waste storage areas;<br>• combustibles have <u>five-foot separation</u> from waste containers<br><u>Attributes of ignition source control include</u>:<br>• <u>restrictions on smoking</u> in facilities;<br>• <u>hot work permits</u> | • Reduces the likelihood of fires and flammable gas explosions in areas containing staged, stored, or in-process radioactive material to *Unlikely.*<br>• Reduces the likelihood of metal waste container fire-induced lid loss associated with expected fires to *Beyond Extremely Unlikely.*<br>• Reduces the likelihood of container- to-container fire propagation associated with expected fires to *Beyond Extremely Unlikely.*<br>• Reduces the likelihood of seismic-induced fires to *Beyond Extremely Unlikely.*<br>• Preserves the assumption that fires will not propagate beyond a confinement enclosure for RT fire scenarios.<br>• Reduces the likelihood of breaching metal waste containers by direct flame impingement of a gas torch is a *Beyond Extremely Unlikely* event.<br>• Reduces the likelihood of fires larger than 4 MW occurring in a waste management facility are *Beyond Extremely Unlikely.* | AOL 8 | Fire Scenario 1<br>Fire Scenario 2<br>Fire Scenario 3<br>NPH Scenario 1<br>NPH Scenario 2<br>Explosion Scenario 2<br>Aircraft Crash Scenario 1 |

**Table 14-2** Credited Administrative Controls Matrix

| Credited Administrative Control | Safety Feature | TSR AC | Scenario |
|---|---|---|---|
| ***Flammable Gas Use***<br>A flammable gas use program shall be implemented.<br>Attributes of flammable gas use program include:<br>• flammable gas inventory in rooms of less than 12,000 $ft^3$ is prohibited;<br>• flammable gas inventory in rooms greater than 12,000 $ft^3$ shall be limited to 150 $ft^3$;<br>• flammable gas inventory in vaults while SNM is present is prohibited. | Reduces the MAR associated with facility explosions to containers breached by falling debris versus direct explosion impacts.<br>Preserves the assumption direct flame impingement fires are *Beyond Extremely Unlikely.* | AOL 9 | Explosion Scenario 2 |
| ***Criticality Safety (Criticality Limit)***<br>Glovebox enclosures contain no more than 320 grams WG Pu equivalent. | Sets the potential MAR for the RT fire and spill scenarios impacting TRU waste in a glovebox. | AC 5.6 | Fire Scenario 3<br>Spill Scenario 4 |
| ***Radiation Protection***<br>The Waste Management Facilities will comply with the Radiation Protection program. | Reduces radiological exposure to the IW in SH spill scenarios. | AC 5.6 | Spill Scenario 1<br>Spill Scenario 2<br>Spill Scenario 3 |
| ***Life Safety/Disaster Warning (LS/DW) System*** | Reduces radiological exposure to the IW. | AC 5.5 | All Scenarios |
| ***Emergency Response***<br>Waste Management Facilities will develop facility-specific Emergency Plans. | Reduces radiological exposure to the IW.<br>Prevents exposure of the IW to snow load-induced facility collapse. | AC 5.5 | All Scenarios |

## 14.5 TSR DERIVATION

The TSRs were developed as a result of the hazard evaluation and accident analysis processes presented in this NSTR. The process used to develop the TSRs is depicted in Figure 14-1. There are four inputs to the TSRs: (1) recognized controls, (2) credited controls, (3) derived controls, and (4) Site management controls as defined below.

***Recognized Controls*** were identified during the hazard identification step of the safety analysis. Recognized controls helped to determine whether identified hazards could be characterized as *standard industrial hazards*, requiring no further evaluation, or as hazards requiring further evaluation. Recognized controls are typically covered by the Safety Management Programs (SMPs) that enhance defense-in-depth and worker safety and are not usually driven by the individual accident scenario evaluations. Examples of recognized controls include drum handling equipment design and health and safety practices addressing control of such equipment.

***Credited Controls*** are those controls specifically identified and credited during evaluation of postulated accident scenarios. Credited controls include LCOs (and associated SRs), Design Features, and ACs that support the accident scenario frequency and consequence assumptions presented in the accident analysis tables. Examples of credited controls include the Automatic Sprinkler System and control of combustible materials and ignition sources.

***Derived Controls*** are any additional controls that were identified during evaluation of the accident scenarios. Derived Controls further reduce the risk of the postulated accident scenarios from what is presented in the accident evaluation section. Derived controls are similar to credited controls; the distinction between these types of controls deals with the point in the analysis where the control is defined. An example of a derived control is the Filtered Exhaust Ventilation System.

Finally, ***Site Management Controls*** help assure the continued implementation and maintenance of the TSRs. Examples of Site management controls include Organization and Management, Configuration Management, Quality Assurance, Training, and Nuclear Safety.

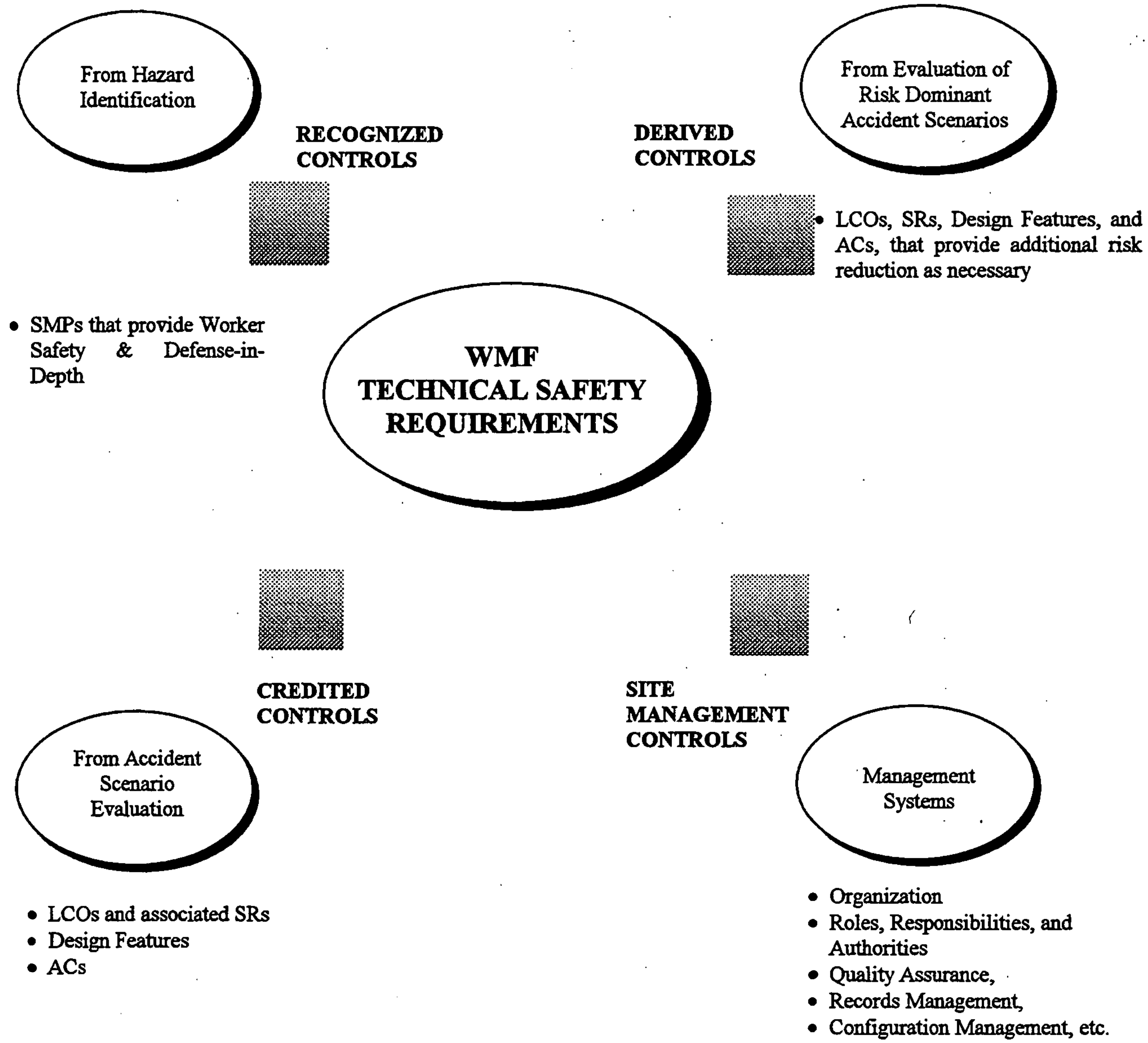


**Figure 14-1** Development of Technical Safety Requirements

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